DOE/NASA CONTRACTOR REPORT

DOE/NASA CR-150741

DESIGN AND INSTALLATION PACKAGE FOR THE SUNMAT FLAT PLATE SOLAR COLLECTOR

Prepared from documents furnished by

Calmac Manufacturing Company
150 S. Van Brunt Street
Englewood, New Jersey 07631

Under Contract NAS8-32253 with

National Aeronautics and Space Administration
George C. Marshall Space Flight Center, Alabama 35812

For the U. S. Department of Energy

U.S. Department of Energy

Solar Energy

TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO. DOE/NASA CR-150741	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.
4. TITLE AND SUBTITLE Design and Installation Package for the Sunmat Flat Plate Solar Collector		5. REPORT DATE March 1978 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)		8. PERFORMING ORGANIZATION REPORT #
9. PERFORMING ORGANIZATION NAME AND ADDRESS Calmac Manufacturing Company 150 S. Van Brunt Street Englewood, New Jersey 07631		10. WORK UNIT NO. 11. CONTRACT OR GRANT NO. NAS8-32253
12. SPONSORING AGENCY NAME AND ADDRESS National Aeronautics and Space Administration Washington, D. C. 20546		13. TYPE OF REPORT & PERIOD COVERED Contractor Report 14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

This work was done under the technical management of Mr. John M. Caudle, George C. Marshall Space Flight Center, Alabama.

16. ABSTRACT

This report contains the information used in evaluating the design of the Sunmat Liquid Flat Plat Plate Solar Collector developed by Calmac Manufacturing Company. Included in this package are the Subsystem Performance Specification, Installation, Operation and Maintenance Manuals, collector sizing guides, and detailed drawings of the single-glazed collector.

17. KEY WORDS	18. DISTRIBUTION STATEMENT Unclassified-Unlimited William A. Brooksbank, Jr. WILLIAM A. BROOKSBANK, JR. Mgr, Solar Heating and Cooling Project Office

19. SECURITY CLASSIF. (of this report)	20. SECURITY CLASSIF. (of this page)	21. NO. OF PAGES	22. PRICE
Unclassified	Unclassified	61	NTIS

MSFC - Form 3292 (Rev. December 1972)

For sale by National Technical Information Service, Springfield, Virginia 22151

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CALMAC MFG. CORP.

FLATE PLATE COLLECTOR

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Revision 1
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SUBSYSTEM PERFORMANCE SPECIFICATION

1.0 INTRODUCTION

This Performance Specification establishes the requirements for the design and performance of a flat plate collector subsystem for use with solar heating systems. It designates the Interim Performance Criteria applicable to the subsystem and defines the deviations. The appendices specify the performance for each subsystem and the installation drawings.

2.0 APPLICABLE DOCUMENTS

2.1 Government Documents

Interim Performance Criteria for Solar Heating and Combined Heating/Cooling Systems and Dwellings, January 1, 1975. U. S. Department of Housing and Urban Development.

2.2 Contractor Documents

SE-1223 Collector Sizing Guide for Solar Energy Systems, December 1977

SE-1298 SUNMAT Field Assembled Solar Collector Installation, Operation, Service Manual & Applications Guide, December 1977

SE-3056 SUNMAT Solar Collector Installation, Operation and Service Manual Applications Guide, December 1977

2.3 Other Documents

None

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SUBSYSTEM PERFORMANCE SPECIFICATION

3.0 APPLICATION OF INTERIM PERFORMANCE CRITERIA BY TYPE OF SUBSYSTEM

The application of each paragraph of the Interim Performance Criteria to each type subsystem is provided in the following table:

Table I - Residential Subsystems

4.0 DEVIATIONS FROM INTERIM PERFORMANCE CRITERIA

There are no deviations to the Interim Performance Criteria.

5.0 GOVERNMENT FURNISHED PROPERTY

None.

6.0 GOVERNMENT DIRECTED REQUIREMENTS

None.

7.0 SUBSYSTEM APPENDICES

Appendix A - Technical Performance Requirements

8.0 WARRANTY

Contractor warrants for a period of five years that the solar collector materials will be free of defects in quality and workmanship. Warranty is limited to shipping replacement parts prepaid which in the contractor's opinion are required to correct such defects. No field labor is included.

APPENDIX A - Technical Performance Requirements

The solar collector will collect a minimum of 500 BTU of energy per day per square foot of collector surface at an inlet fluid temperature equal to or greater than 130°F for the following conditions:

Tilt Angle	- 50° with Horizontal
Azimuth	- Due South
Ambient Temp.	- 40°F. Average
Wind Velocity	- 600 Ft. Per Min. Average
Date	- November 21
Noon Solar Flux Normal to Collector Surface	- 290 BTU Per Hour Sq. Ft
Longitude	- 74°
Latitude	- 41°

Based on aperature area 59%

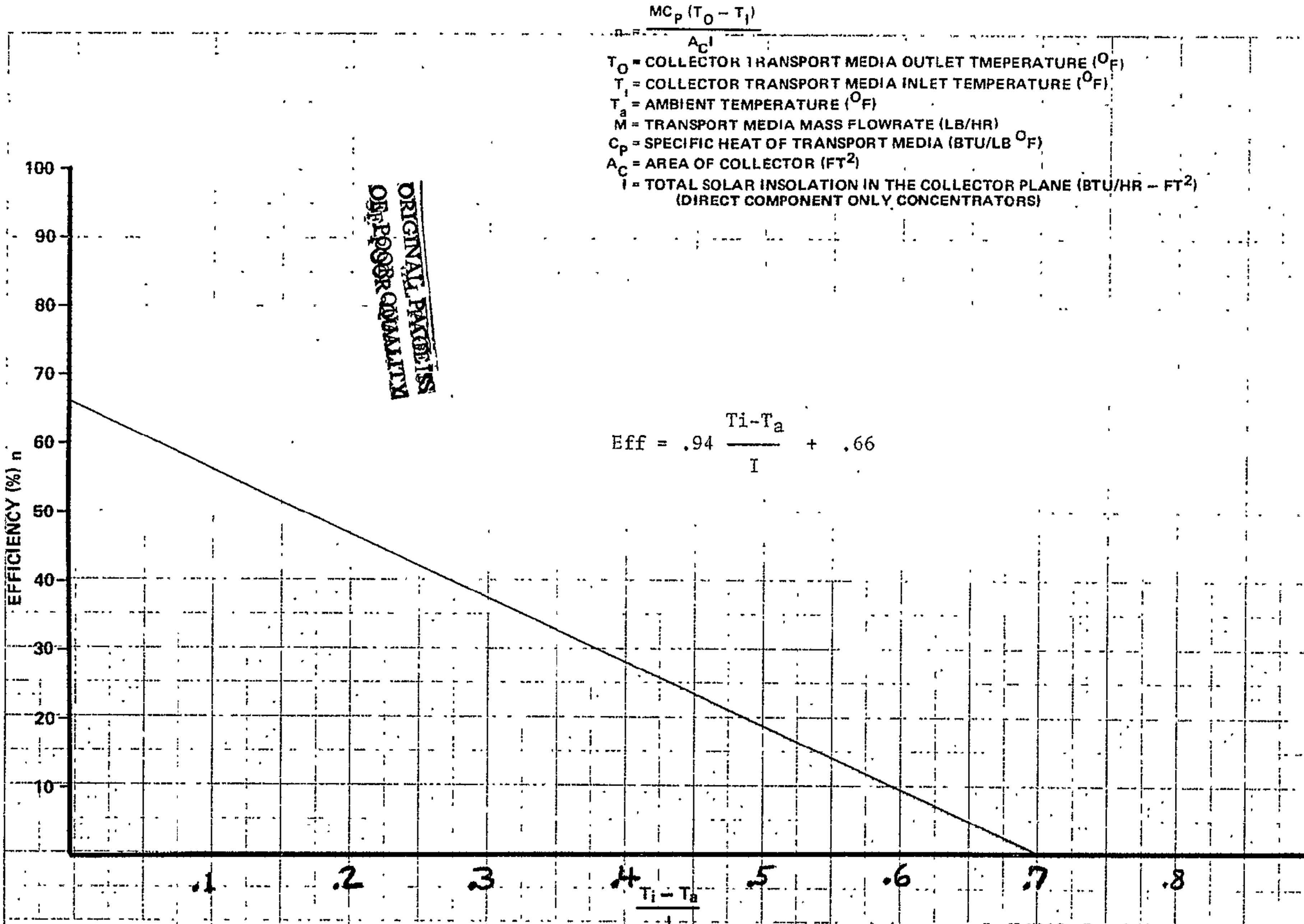

FIGURE 1 EFFICIENCY AS A FUNCTION OF OPERATING CONDITIONS
PERFORMANCE MUST BE ABOVE LINE

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TABLE I

RESIDENTIAL SUBSYSTEMS, INTERIM PERFORMANCE CRITERIA SUMMARY

SHEET 1 OF 6

SUBSYSTEM APPLICATION

A – APPLICABLE TO TYPE SYSTEMS INDICATED

NA – NOT APPLICABLE

TYPE SYSTEMS

H – HEATING

HC – HEATING AND COOLING

HW – HOT WATER

RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS H	HC	HW
1.1 H and HC Performance	NA	NA	NA
1.1.1 Heating Design Temperatures	NA	NA	NA
1.1.2 Cooling Design Temperatures	NA	NA	NA
1.1.3 Relative Humidity and Water Vapor Pressure	NA	NA	NA
1.1.4 Solar Contribution	NA	NA	NA
1.1.5 Operation Impairment	NA	NA	NA
1.2 HW System/Subsystem Performance	NA	NA	NA
1.2.1 Water Design Temperature	NA	NA	NA
1.2.2 Storage Design Capacity	NA	A	A
1.2.3 Solar Contribution	NA	NA	NA
1.2.4 Operational Impairment	A	A	A
1.3 Collector Performance	A	A	A
1.3.1 Collector Efficiency	A	A	A
1.4 Thermal Storage	A	A	A
1.4.1 Storage Capacity	A	A	A
1.5 Habitability of Occupied Spaces	NA	NA	NA
1.5.1 Heat or Humidity Transfer Effects	NA	NA	NA
1.6 Energy Transport Efficiency	NA	NA	NA
1.6.1 Thermal Losses and Electrical Power	NA	NA	NA
1.7 Control	NA	NA	NA
1.7.1 Installation and Maintenance	NA	NA	NA
1.7.2 Manual Adjustment	NA	NA	NA
1.7.3 Inhabited Space Temperature	NA	NA	NA
1.7.4 Hot Water Temperature	NA	NA	NA
1.8 Auxiliary Energy	NA	NA	NA
1.8.1 Design Loads	NA	NA	NA

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RESIDENTIAL SUBSYSTEMS, INTERIM PERFORMANCE CRITERIA SUMMARY

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SUBSYSTEM APPLICATION

A – APPLICABLE TO TYPE SYSTEMS INDICATED

NA – NOT APPLICABLE

TYPE SYSTEMS

H – HEATING

HC – HEATING AND COOLING

HW – HOT WATER

RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS		
	H	HC	HW
2.1 System Design Conditions	A	A	A
2.1.1 Equipment Capabilities	A	A	A
2.1.2 Noise or Erosion - Corrosion	A	A	A
2.1.3 Operating Conditions	A	A	A
2.1.4 Fluid Flow in Collectors	A	A	A
2.1.5 Entrapped Air	NA	A	A
2.1.6 Thermal Expansion of Fluids	NA	A	A
2.1.7 Pressure Drops	A	A	A
2.1.8 Condensate Removal	NA	A	NA
2.2 Mechanical Stresses	A	A	A
2.2.1 Vibration Stress Levels	A	A	A
2.2.2 Vibration from Moving Parts	A	A	A
2.2.3 Water Hammer	NA	NA	NA
2.2.4 Vacuum Relief Protection	A	A	A
2.2.5 Thermal Changes	A	A	A
2.2.6 Flexible Joints	NA	A	A
2.3 Leakage Prevention	A	A	A

RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS		
	H	HC	HW
2.3.1 Pressure Test: Nonpotable Fluids	A	A	A
2.3.2 Pressure Test: Potable Water	NA	A	A
2.3.3 Air Transport Systems	NA	A	A
2.4 Collector Adjustment	A	A	A
2.4.1 Orientation and Tilt	A	A	A
2.4.2 Mutual Shadowing	NA	A	A
2.5 Subsystem Isolation	NA	NA	NA
2.5.1 Shutdown in Multifamily Housing	NA	NA	NA
2.6 Heat Transfer Fluid Quality	NA	NA	NA
2.6.1 Liquid Quality	A	NA	NA
2.6.2 Air Quality	NA	NA	NA
2.6.3 Fluid Quality	NA	NA	NA
2.6.4 Freezing Protection	A	NA	NA
2.7 Piping Supports	A	NA	NA
2.7.1 Applicable Plumbing Standards	A	A	A
2.8 Excessive Pressure and Temperature Protection	A	A	A
2.8.1 Relief Valves and Vents	A	NA	NA
3.1 Structural Design Basis	A	A	A

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RESIDENTIAL SUBSYSTEMS, INTERIM PERFORMANCE CRITERIA SUMMARY

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SUBSYSTEM APPLICATION

A – APPLICABLE TO TYPE SYSTEMS INDICATED

NA – NOT APPLICABLE

TYPE SYSTEMS

H – HEATING

HC – HEATING AND COOLING

HW – HOT WATER

RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS H	HC	HW
3.1.1 Applicable Standards	A	A	A
3.1.2 Service Loads	A	A	A
3.2 Failure Loads and Load Capacity	A	A	A
3.2.1 Ultimate Load Combinations	A	A	A
3.2.2 Ice Loads	A	A	A
3.2.3 Vehicular Loads	NA	A	A
3.2.4 Load Capacity	A	A	A
3.3 Damage Control	A	A	A
3.3.1 Resistance to Damage	A	A	A
3.3.2 Glazing Design	NA	A	A
3.4 Cyclic Loads	A	A	A
3.4.1 Deflection Limitations	A	A	A
3.5 Cutting of Structural Elements	NA	NA	NA
3.5.1 Design Provisions	NA	NA	NA
3.6 Creep and Residual Deflection	NA	NA	NA
3.6.1 Deflection Limitations	NA	NA	NA
3.7 Hail Resistance	A	A	A
3.7.1 Hail Size and Loading	A	A	A
3.8 Constraint Loads	A	A	A

RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS H	HC	HW
3.8.1 Foundation Settlement	A	A	A
3.9 Ponding Condition	A	A	A
3.9.1 Design Provisions	NA	A	A
4.1 Plumbing and Electrical Installation	A	A	A
4.1.1 Plumbing Codes	A	A	A
4.1.2 Electrical Codes (for sensors)	A	A	A
4.2 Fail-Safe Controls	A	A	A
4.2.1 System Failure Prevention	A	A	A
4.2.2 Automatic Pressure Relief Valves	A	A	A
4.3 Fire Safety	A	A	A
4.3.1 Applicable Fire Standards	A	A	A
4.3.2 Penetrations through Fire Rated Assemblies	NA	NA	NA
4.4 Toxic	A	A	A
4.4.1 Provisions of Catch Basins	A	A	A
4.4.2 Detection of Toxic and Flammable Fluids	NA	NA	NA
4.5 Safety	NA	NA	NA
4.5.1 Emergency Egress and Access	NA	NA	NA
4.5.2 Identification and Location of Controls	A	A	A

SUBSYSTEM PERFORMANCE [illegible]CIFICATION

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SUBSYSTEM APPLICATION

A -- APPLICABLE TO TYPE SYSTEMS INDICATED

NA -- NOT APPLICABLE

TYPE SYSTEMS

H HEATING

HC HEATING AND COOLING

HW HOT WATER

RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS		
	H	HC	HW
4.6 Protection of Potable Water & Circulated Air	A	A	A
4.6.1 Contamination by Materials	A	A	A
4.6.2 Separation of Circulation Loops	A	A	A
4.6.3 Backflow Prevention	NA	A	A
4.6.4 Growth of Fungi	A	A	A
4.7 Excessive Surface Temperatures	A	A	A
4.7.1 Protection from Heated Components	A	A	A
5.1 Effects of External Environment	A	A	A
5.1.1 Solar Degradation	A	A	A
5.1.2 Soil Corrosion	NA	A	A
5.1.3 Airborne Pollutants	A	A	A
5.1.4 Dirt Retention on Cover Plate Surface	A	A	A
5.1.5 Abrasive Wear	A	A	A
5.1.6 Fluttering by Wind	A	A	A
5.2 Temperature & Pressure Resistance	A	A	A
5.2.1 Thermal Degradation	A	A	A
5.2.2 Deterioration of Heat Transfer Fluids	A	A	A

RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS		
	H	HC	HW
5.2.3 Thermal Cycling Stresses	A	A	A
5.2.4 Leakage	A	A	A
5.2.5 Deterioration of Gaskets and Sealants	A	A	A
5.2.6 Transmission Losses Due to Outgassing	A	A	A
5.3 Chemical Compatibility of Components	A	A	A
5.3.1 Materials/Transfer Fluid Compatibility	A	A	A
5.3.2 Corrosion of Dissimilar Materials	A	A	A
5.3.3 Corrosion by Leachable Substance	A	A	A
5.3.4 Effects of Decomposition Products	A	A	A
5.4 Components Involving Moving Parts	A	A	A
5.4.1 Wear and Fatigue	A	A	A
6.1 Accessibility for Maintenance	A	A	A
6.1.1 Access for System Maintenance	A	A	A
6.1.2 Access for System Monitoring	A	A	A
6.1.3 Draining and Filling of Liquids	A	A	A
6.1.4 Flushing of Liquids Subsystems	A	A	A

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SUBSYSTEM APPLICATION

A – APPLICABLE TO TYPE SYSTEMS INDICATED

NA – NOT APPLICABLE

TYPE SYSTEMS

H - HEATING

HC – HEATING AND COOLING

HW – HOT WATER

RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS		
	H	HC	HW
6.1.5 Filters	A	A	A
6.1.6 Potable Water Shutoff	NA	NA	NA
6.2 Installation, Operation and Maintenance Manual	A	A	A
6.2.1 Installation Instructions'	A	A	A
6.2.2 Maintenance and Operation Instructions	A	A	A
6.2.3 Maintenance Plan	A	A	A
6.2.4 Replacement Parts	A	A	A
6.3 Repair and Service Personnel	A	A	A
6.3.1 Maintenance of H and HC Systems	A	A	A
6.3.2 Maintenance of DHW System	A	A	A
7.1 Design	NA	NA	NA
7.1.1 Dwelling Design	NA	NA	NA
7.1.2 Mobile Home Design	NA	NA	NA
7.1.3 Site Design	NA	NA	NA
7.1.4 Passive Use of Solar Energy	NA	NA	NA
7.2 Adequate Space	NA	NA	NA
7.2.1 Collector Area	NA	NA	NA
7.2.2 Storage Area	NA	NA	NA
7.2.3 Utility Chases	NA	NA	NA
7.3 Functioning of Dwelling Site	NA	NA	NA
7.3.1 Space Use	NA	NA	NA
7.3.2 Shading of Adjacent Structures	NA	NA	NA
7.3.3 Impace of Environment	NA	NA	NA
7.3.4 View	NA	NA	NA
8.1 Interference with Mechanical Operation	NA	NA	NA
8.1.1 Blockage of Solar Subsystem	NA	NA	NA
8.1.2 Shading of Collector	NA	NA	NA
8.1.3 Sensor Location	NA	NA	NA
8.2 Mechanical & Electrical Functioning of Dwelling and Site	NA	NA	NA
8.2.1 Exhaust and Venting	NA	NA	NA
8.2.2 Utilities	NA	NA	NA
8.3 Mechanical & Electrical Functioning of Connections	NA	NA	NA
8.3.1 Plumbing Connections	A	NA	N

TABLE I

RESIDENTIAL SUBSYSTEMS, INTERIM PERFORMANCE CRITERIA SUMMARY

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SUBSYSTEM APPLICATION

A – APPLICABLE TO TYPE SYSTEMS INDICATED

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TYPE SYSTEMS

H – HEATING

HC – HEATING AND COOLING

HW – HOT WATER

RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS H	HC	HW	RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS H	HC	HW
8.3.2 Electrical Connections	NA	NA	NA	11.2.2 Heat and Moisture	A	A	A
9.1 Structural Integrity	NA	NA	NA	11.2.3 Exterior Penetrations	NA	NA	NA
9.1.1 Movements in Adjacent Structures	NA	NA	NA	11.3 Durability and Reliability of Connections	NA	NA	NA
9.2 Structural Integrity of Dwelling	NA	NA	NA	11.3.1 Material Compatibility	A	A	A
9.2.1 Loads	NA	NA	NA	12.1 Maintainability of H, HC, HW Systems	NA	NA	NA
9.2.2 Penetration of Structural Members	NA	NA	NA	12.1.1 Accessibility	NA	NA	NA
9.3 Structural Connections	NA	NA	NA	12.1.2 Misuse	NA	NA	NA
9.3.1 Structural Connections	NA	NA	NA	12.1.3 Permanent Maintainance Accessories	NA	NA	NA
9.3.2 Brittle Subsystem	NA	NA	NA	12.2 Maintainability of Dwelling and Site	NA	NA	NA
9.3.3 Strength and Stiffness	NA	NA	NA	12.2.1 Accessibility	NA	NA	NA
10.1 Safety of Dwelling and Site	NA	NA	NA	12.2.2 Ice Dams	NA	NA	NA
10.1.1 Fire	NA	NA	NA	12.3 Connections	NA	NA	NA
10.1.2 Accidents	NA	NA	NA	12.3.1 Accessibility	NA	NA	NA
11.1 Durability	NA	NA	NA	13.1 Visual Characteristics of Dwelling and Site	NA	NA	NA
11.1.1 Vegetation	NA	NA	NA	13.1.1 Dwelling	NA	NA	NA
11.2 Durability and Reliability of Dwelling and Site	NA	NA	NA	13.1.2 Neighborhood	NA	NA	NA
11.2.1 Chemical Corrosion	A	A	A				

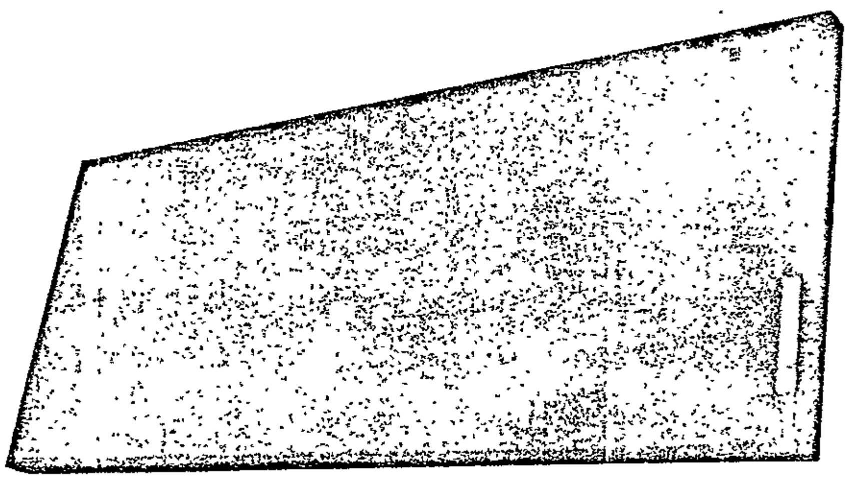
INSTALLATION, OPERATION AND MAINTENANCE MANUAL

CALMAC

TECHNICAL GUIDE
SE-3056
December, 1977

SOLAR ENERGY

SUNMAT Solar Collector
Installation, Operation and Service Manual



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This Technical Guide is written to provide a complete and comprehensive procedure for the installation of the SUNMAT Solar Collector. It is not the intent of this guide to exclude sound and proven methods of installation by contractors who have, through experience and past performance, developed an efficient method of installation expertise.

ALL work must be performed in accordance with LOCAL, STATE and NATIONAL codes.

CALMAC MANUFACTURING CORPORATION
Box 710, 150 S. Van Brunt St., Englewood, N.J. 07631 • (201) 569-0420 • (212) 586-5178

A. General

1 The SUNMAT Solar Collector has been specially designed for space heating and other solar applications requiring large collector areas. The panels are custom-built to fit the dimensions of the roof--a feature that speeds installation and improves esthetics. The panels can also be built in very large sizes--up to 4' by 25'. This means lower costs for plumbing and installation The extensive use of synthetic materials makes them very lightweight and reduces corrosion problems. The special zipper lock feature allows easy access to the absorber in the event servicing is necessary.

B. Collector Sizing

1. The proper sizing of a collector system is a complex process and a number of acceptable methods are available. For a proven, workable procedure refer to CALMAC Technical Guide SE-1223. The efficiency of the collector--a key input in the sizing calculations--is shown in Figure 1-1.

C. Damage in Transit

1. Upon receipt of shipment of this material, inspect all cartons for external damage. If external damage is noted, open the carton and inspect for damage to equipment. Mark the number of cartons received in this condition on the delivering carrier's waybill, and request the services of the inspector.

2. If upon opening a carton concealed damage is discovered, open the entire shipment and note all equipment so damaged. Contact the delivering carrier and request inspection of the damaged equipment. Do not destroy the carton as the inspector from the freight company will need this to determine the reason for damages.

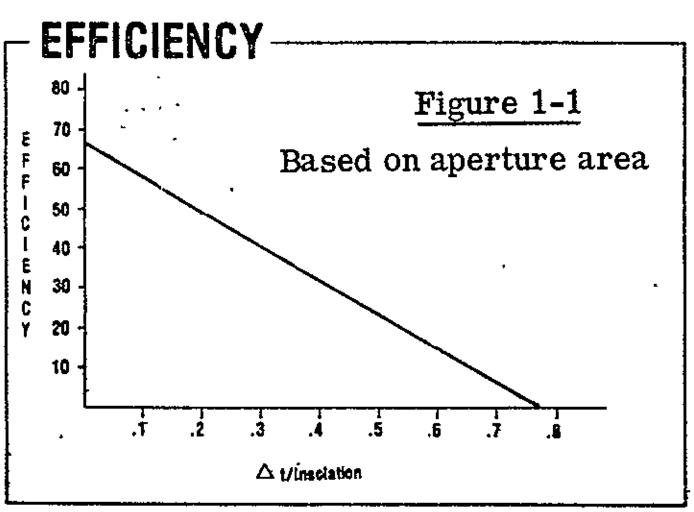


Figure 1-1

Based on aperture area

3. Normally, claims for any and all damages should be filed with the freight company within five working days after receipt of shipment.

4. Since all materials are sold FOB factory, it is the responsibility of the consignee to file claims with the delivering carrier for materials received in damaged condition.

D. System Design

1. Air Vent. An air vent should be installed at the highest point in the supply or return line in order to release air trapped in the piping.

2. Expansion Tank. An expansion tank is required in the supply or return line to allow for thermal expansion and contraction of the heat transfer fluid.

3. Pressure Drop. In sizing pumps for systems using water as the heat transfer fluid the pressure drop through the collector can be determined from Figure 1-3. For systems using anti-freeze heat transfer fluids, the pressure drops should be adjusted based on data provided by the supplier of the heat transfer fluid.

4. Relief Valves. A temperature relief valve set to open at 210°F and a pressure relief valve set to open at 20 PSI must be included in either the supply or return line. Ordinarily the pressure relief valve is located indoors and connected to a catch basin. The appearance of liquid in the catch basin provides evidence of a malfunction, and in closed loop systems the possible need to add more heat transfer fluid.

5. Strainers. A strainer should be installed in the supply line to the collector. This strainer should be checked one week after startup and annually thereafter.

6. Pressures and Flows. The maximum recommended operating pressure is 20 PSI. In practice this means that the collector should not be connected directly to a water main. Subjecting the system continuously to pressure above 20 PSI will cause the SUNMAT tubing to stretch over time and may lead to leaks in the system.

The minimum recommended flow rate throughaa collector is 2 GPM to insure optimum efficiency. The maximum recommended flow rate through a collector is 5 GPM. Higher flows will create velocities through the headers which may cause whistling and/or erosion.

7. Gauges. In closed loop systems a pressure gauge reading the system pressure (usually 20 PSI) is recommended. A drop in system pressure usually indicates a leak in the system.

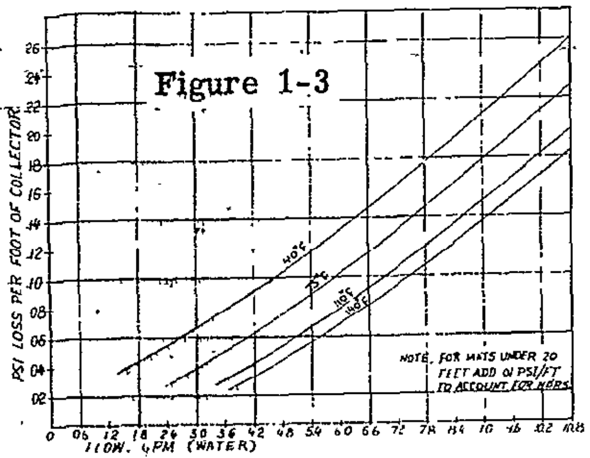


Figure 1-3

E. Installing the SUNMAT Solar Collector

1. The inlet and outlet plumbing connections to the SUNMAT collector are located at the same end of the collector. The 3/4" NPT connections are located either on the right or left side, both sides, or the back side of the collector. The configuration, which depends on where the pipes will best penetrate the roof, is specified at the time the order is placed with the factory.

2. The collector may be mounted vertically or horizontally with the plumbing connections at either the top or the bottom. Because the inside diameter of the collector tubing is small, trapped air is readily swept away when heat transfer fluid is circulated through the system, so the headers may be located at the bottom of a vertically mounted collector.

3. When two or more collectors are to be used side-by-side, it is permissible to make the inlet/outlet connections to one collector through one other collector. In this way four collectors can be hooked up to one supply and return line. See Figure 1-2.

4. For esthetic reasons care should be taken to insure that collector sides are parallel to adjacent roof lines. A chalk line is also helpful in getting the correct alignment. It is also helpful to have someone on the ground visually confirm the alignment.

5. If the roof structure underlayment is plywood and is in good condition, the collectors may be bolted to the plywood. The most secure connection is to bolt the collectors into the rafters. Holes in the collector mounting flange should be made to coincide with the location of the rafters. Holes in the flange should be 3/8" diameter. To allow for differential expansion they should also generally be elongated (up to 1" for 25-foot long collectors). To locate the rafters, use a stud finder or tap the roof with a hammer. The more solid sound indicates the rafter. Once the general location of the rafters has been determined, a nail can be driven through the roof to more precisely locate the rafters. These rafter location nails can be driven through a 2" x 4" that will also serve as a temporary horizontal support at the bottom of the collectors while they are being bolted to the roof.

6. The collectors can now be brought up onto the roof. One way to bring the collectors onto the roof is to slide them up a ladder. With one person at the top of the ladder pulling and a second person pushing from below, the collector can be moved into place relatively easily.

7. Drill holes through the roof into the rafters. If 1/4" diameter lag bolts are used (min. recommended diameter) then the holes drilled into the roof should be several drill sizes smaller. After the holes are drilled into the rafter they should be filled with silicone sealant before the bolts are inserted. The bolts should be of sufficient length that they penetrate the plywood underlayment, and engage a rafter by at least 2".

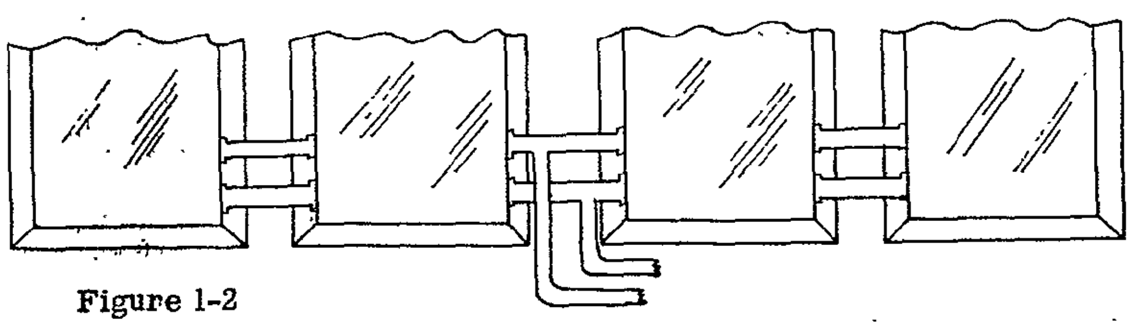


Figure 1-2

8. The collectors should be spaced a minimum of 1/4" apart so that thermal expansion and contraction of the frame does not disturb the mounting.

9. The manifold inlet and outlet connections are 3/4" NPT. Teflon tape is recommended as a sealant for all threaded connections. Do not insulate the piping or add flashing until the system is pressure-tested. Finding the leaks under flashing and insulation is quite difficult.

10. All roof penetrations should be sealed a second time to insure against leaks. Silicone sealant is a good choice.

11. Remove the nailer at the bottom of the collector that was used to hold the collectors on the roof and fill the nail holes with silicone sealant.

F. REPAIRS AND MAINTENANCE

1. No routine maintenance is required, but the system should be checked at least annually for breakdowns in the system.

2. Rain should keep the collector cover relatively dirt-free. However, if dirt or dust accumulates, it may be necessary to hose and wash the cover. Normal wind and water gradually abrade the cover panel, and to insure optimum performance every five to seven years the panel must be spray-coated with Kal-Lac, a fast-drying liquid-applied by roller, spray or brush.

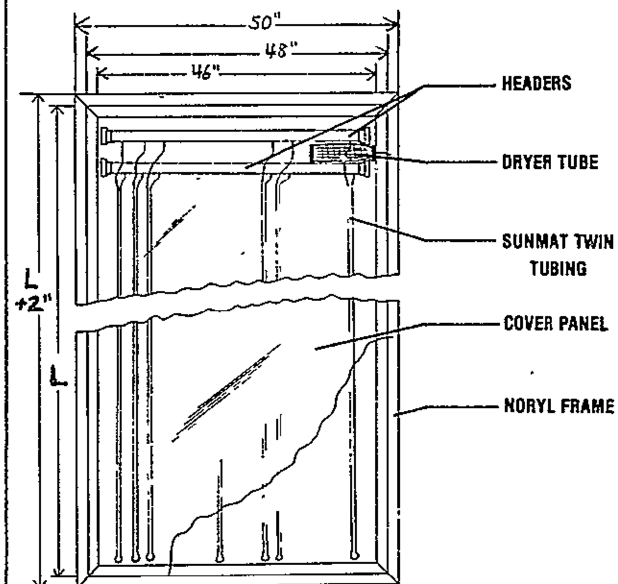
3. Any leaks that may develop in the tubing system can be repaired with copper splicer tubes and Stimpson clamps from the repair kit. To make this type of repair a heavy, wide-bladed screwdriver should be used to pop the glazing frame piece off from the side wall. It is usually best to start at one corner. After the plastic zipper lock is undone, the cover can be rolled back to expose the tubing. To repair the tubing the damaged piece should be cut out and a splicer tube put in its place and fastened with Stimpson clamps at either end. Then the glazing should be repositioned in place and the side and top plastic frame pieces snapped back together with a rubber mallet starting at the corners and finishing midway between.

4. Because of the small diameter of the SUNMAT tubing, capillary action prevents complete draining of the tubing. In the event the collector must be completely drained, air pressure must be used to force fluid out of the tubing grid.

5. Every several years flushing the system may be advisable. Water run through the system at 40 PSI is generally adequate. Connections for flushing should be included at the time of installation.

6. Heat Transfer Fluids. Heat transfer fluids should be maintained in accordance with specifications provided by the manufacturer. The SUNMAT system is compatible with glycol anti-freezes. Contact CALMAC before using other anti-freezes.

SPECIFICATIONS



COVER PLATE:
Fiberglass-reinforced polyester, .040"
Transmissivity: 88% at 0°, 78% at 45°
Wind Load Design: 100 MPH

ABSORBER:
Surface: Black, high temperature urethane coating
Aluminum Sheet: .002" thick
Tubing: 5/16" OD EPDM dual tubing
—Tube spacing 1½" on center
—Manifold and outlet ¾" OD type L copper
—U-bends and manifold-to-tubing connections ¼" copper

INSULATION:
High temperature (350°F) rigid fiberglass
Density: 4.0 lbs/ft³
2" on bottom, R = 9 1" on sides, R = 4.5 @70°F

DESICCANT:
Silica gel in 3/4" x 10" wire mesh tube

COLLECTOR FRAME:
.125" thick Noryl extrusion

MOUNTING PROVISIONS:
1" flange around total perimeter
External plumbing connections ¾" standard pipe thread

FLUID:
Capacity 03 gallons/ft²

MAXIMUM OPERATING TEMPERATURE: 210°F

MAXIMUM ALLOWABLE TEMPERATURE: 300°F

DESIGN LIFE OF COLLECTOR: 20 years

FLUID PRESSURES:
Maximum operating pressure: 20 PSI
Tubing test pressure: 80 PSI

FLOW RATES:
.018 GPM/square foot of mat
Minimum flow rate: 2.0 GPM

NOMINAL PRESSURE DROP:
.16 PSI per foot of length of mat

TECHNICAL GUIDE

SE-1298

December, 1977

SOLAR ENERGY

SUNMAT Field-Assembled Solar Collector Installation, Operation & Service Manual

INDEX

The SUNMAT Field-Assembled Solar Collector System is a non-metallic single-glazed collector designed to be constructed on site in much larger sizes than conventional factory-assembled panels. The system allows the collector to be tailored to fit the dimensions of any installation and provides economies of scale in construction and plumbing.

The SUNMAT consists of a flexible grid of 30 closely spaced elastomer twin tubes cemented to an insulation board base and covered with a flexible reinforced plastic cover. The grid substitutes for the metal absorber plate used in conventional panel-type collectors.

ALL aspects of this installation must comply with NATIONAL, STATE and LOCAL codes.

The information in this manual has been prepared to save time, obtain the best possible installation and insure continuous trouble-free operation of the collector system.

All materials obtained locally or from suppliers other than CALMAC Manufacturing Corporation must be in accordance with specifications set forth in the Section on Specifications.

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CALMAC MANUFACTURING CORPORATION Box 710 150 S. Van Brunt St., Englewood, N.J. 07631 • (201) 569-0420 • (212) 586-5178

I. GENERAL

A. Collector Sizing

The proper sizing of a collector system is a complex process and a number of acceptable methods are available. For a proven, workable procedure refer to CALMAC Technical Guide SE-1223. The efficiency of the collector--a key input in the sizing calculations--is shown in Figure 1.

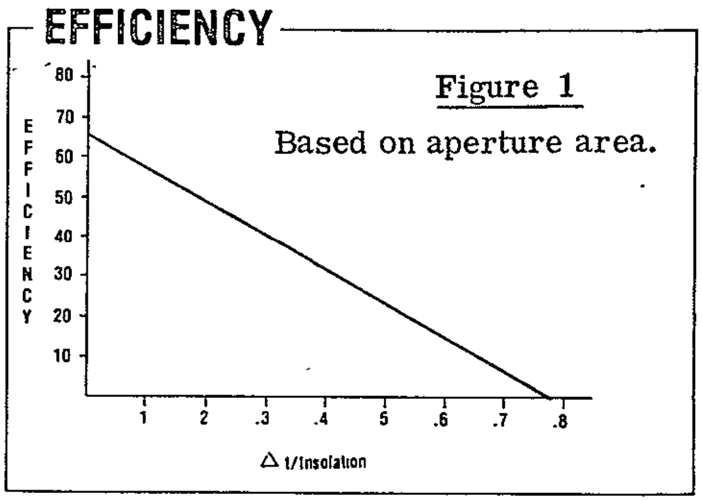


Figure 1

Based on aperture area.

B. Materials and Tools

1. The following materials are required to build the collector:

Item	Quantity
Absorber tubing system (EPDM tubing grid with copper U-bends and headers)	4' x desired length
Absorber cement	One gallon for every 40 square feet
Plastic Cover Panel	4' x desired length
Insulation Board	220% of collector area
Contact Cement	One gallon for every 130 square feet
Insulation Cement	One gallon for every 60 square feet
EPDM Hose	1/2" per square foot of collector
Roofing Mastic	One gallon for every square feet
Condensation Dryers	One for every 200 square feet of collector or fraction thereof
Foil-Faced Tape	Four feet for every four feet of collector length

For further specification on the materials refer to the Specifications Section.

2. The following tools are required to build the collector:

- 12" adjustable wrench
- 12" pipe wrench
- knife
- pair of hand gloves
- bicycle pump or other source of compressed air
- pair of pliers
- measuring tape
- straight edge
- masking tape

C. Damage in Transit

1. Upon receipt of shipment of this material, inspect all cartons for external damage. If external damage is noted, open the carton and inspect for damage to equipment. Mark the number of cartons received in this condition on the delivering carrier's waybill, and request the services of the inspector.

2. If upon opening a carton concealed damage is discovered, open the entire shipment and note all equipment so damaged. Contact the delivering carrier and request inspection of the damaged equipment. Do not destroy the carton as the inspector from the freight company will need this to determine the reason for damages.

3. Normally, claims for any and all damages should be filed with the freight company within five working days after receipt of shipment.

4. Since all materials are sold FOB factory, it is the responsibility of the consignee to file claims with the delivering carrier for materials received in damaged condition.

D. System Design

1. Headering. When two or more collectors are to be used and assembled side by side, it is permissible to connect the header system of one collector to the in and out piping through one other header system. Using a T-connection it is possible to hook four header systems to the same in and out piping. See Figure 2.

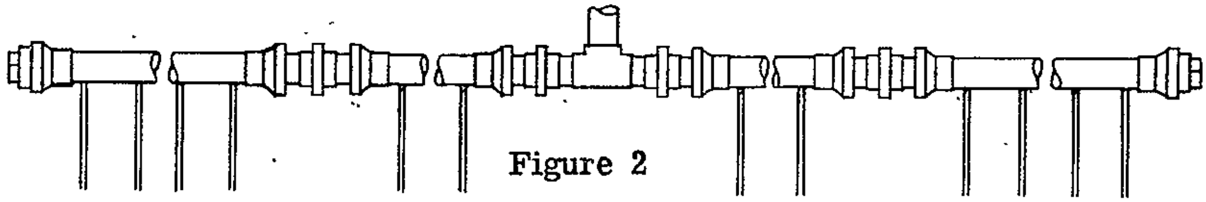


Figure 2

2. Air Vent. An air vént should be installed at the highest point in the supply or return line in order to release air trapped in the piping.

3. Expansion Tank. An expansion tank is required in the supply or return line to allow for thermal expansion and contraction of the heat transfer fluid.

3. Pressure Drop. In sizing pumps for systems using water as the heat transfer fluid the pressure drop through the collector can be determined from Figure 3. For systems using anti-freeze heat transfer fluids, the pressure drops should be adjusted based on data provided by the supplier of the heat transfer fluid.

4. Relief Valves. A temperature relief valve set to open at 210°F and a pressure relief valve set to open at 20 PSI must be included in either the supply or return line. Ordinarily the pressure relief valve is located indoors and connected to a catch basin. The appearance of liquid in the catch basin provides evidence of a malfunction, and in closed loop systems the possible need to add more heat transfer fluid.

5. Strainers. A strainer should be installed in the supply line to the collector. This strainer should be checked one week after startup and annually thereafter.

6. Pressures and Flows. The maximum recommended operating pressure is 20 PSI. In practice this means that the collector should not be connected directly to a water main. Subjecting the system continuously to pressure above 20 PSI will cause the SUNMAT tubing to stretch over time and may lead to leaks in the system.

The minimum recommended flow rate throughaa collector is 2 GPM to insure optimum efficiency. The maximum recommended flow rate through a collector is 5 GPM. Higher flows will create velocities through the headers which may cause whistling and/or erosion.

7. Gauges. In closed loop systems a pressure gauge reading the system pressure (usually 20 PSI) is recommended. A drop in system pressure usually indicates a leak in the system.

II. MOUNTING THE COLLECTOR

A. Mounting the Collector

1. When the system is built on a steeply slanting roof, a scaffolding should always be used. A scaffolding makes the installation much easier and is the safest method.

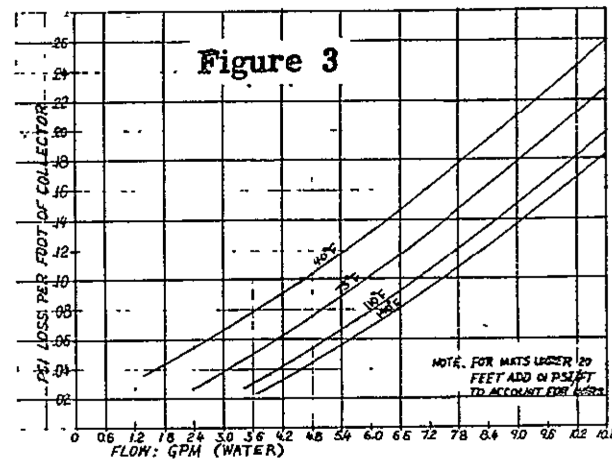


Figure 3

2. The surface on which the SUNMAT system is to be built must be sturdy and flat. As a rule, any normal roofing surface is acceptable as long as the fiberglass insulation which forms the collector bed can be bonded firmly to it with roofing mastic. Since the SUNMAT is quite lightweight, installation on an existing roof does not add appreciably to the load on the roof and is usually quite safe.

3. The layout of the collector installation must take into consideration the size and shape of the space available for the collectors. Each grid of the SUNMAT system is 4' wide. The length of the SUNMAT collector can be any size up to 50' and is therefore cut to fit the available space. In laying out the length, however, it is important to keep in mind that an additional 4" must be allowed beyond the desired length of the absorber system for connecting the headers and U-bends. It is also advisable to keep the length of the SUNMAT as long as practicable since this reduces the cost per square foot.

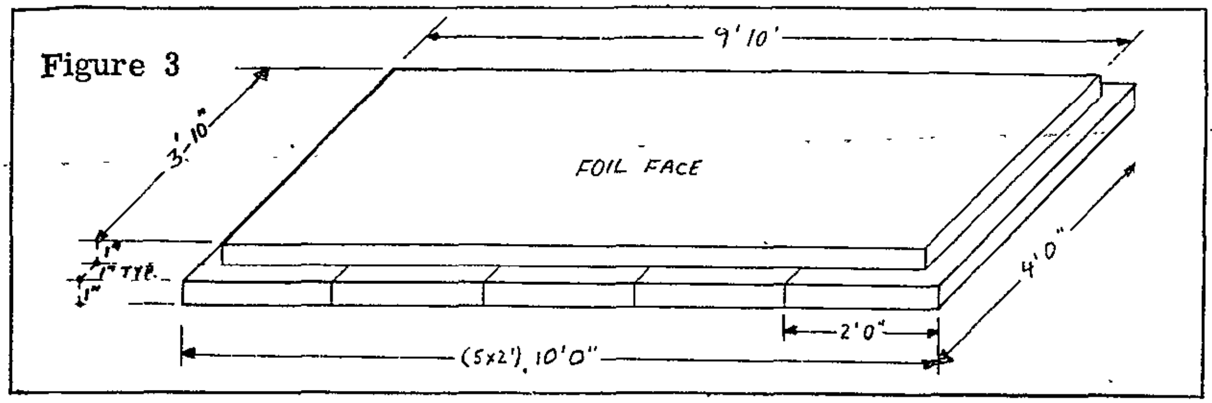
4. The collectors should not be mounted absolutely horizontal since in this position water will pond on the glazing and dirt will accumulate. The minimum recommended slope is 1 in 12.

III. INSTALLATION

A. Constructing the Insulation Bed

1. Cut and build the bed of insulation board. This bed is made of 1" thick foil-faced fiberglass insulation boards cemented face to face. The bottom boards are 2' x 4'. The top boards are 4' x 10' boards that have been factory-outgassed at 350°F for an hour. 1" must be trimmed off these boards to allow for the perimeter walls.

Figure 3



The boards must also be trimmed to the proper length, which is a function of the size of the collector. The top board must be 2" shorter than the bottom board--again, to allow for the perimeter walls. The unfaced sides of the boards are cemented together using the insulation cement to make a 2" board foil-faced on both sides. In order to make one unified section the top and bottom boards are overlapped. The top boards are centered on the bottom board to allow for the perimeter walls. See Figure 3.

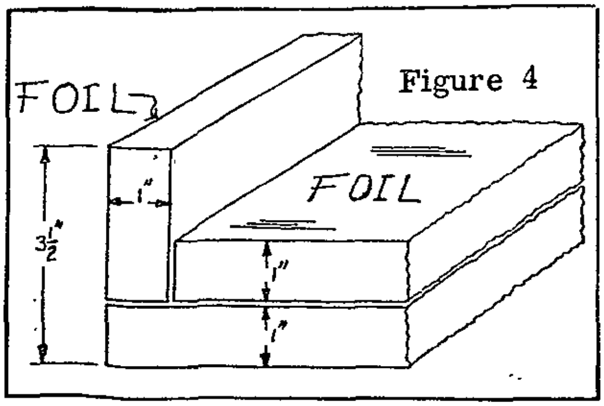
2. Cut and cement the fiberglass insulation perimeter strips to the bed. This wall provides the surface to which the cover panel is cemented. The strips are 2 1/2" wide. The length depends on the size of the collector. Contact cement is used to adhere the strips to the insulation bed. See Figure 4.

3. Mount the insulation board bed on its supporting surface. The bed can be affixed directly to smooth supporting surfaces with ordinary roofing mastic. On surfaces that are irregular, such as shingled roofs, laying down a plywood frame and adhering the bed to the frame with roofing mastic is recommended.

B. Pressure-Testing the SUNMAT for Leaks

1. Pressure-test the tubing system for leaks using a portable air compressor, bicycle pump or canister of compressed air to pressurize the tubing to 40 PSI. One of the headers is supplied with a tank valve to facilitate testing for leaks.

Figure 4



Any leaks should make a hissing sound. Leaks are rare and are usually caused by improper connections between the SUNMAT tubing and the U-bends or headers. Leaks can be detected by applying soapy water and looking for bubbles. Leaks can be repaired by adjusting or replacing the Stimpson clamps. The tubing itself does not generally leak unless it has been damaged in shipment or handling. Leaks in the tubing are repaired with splicers from the repair kit in accordance with instructions in the section on Repairs and Maintenance.

C. Cementing the SUNMAT Grid to the Insulation Bed

1. Position the SUNMAT grid in place. The header end of the mat should be butted against the end border of the bed. If the mat is fairly short, it can be placed directly on the insulation. If it is long, it may be easier to roll it off the shipping roll and onto the insulation bed. The header and U-bend ends of the mat should be secured in place with a piece of foil-faced tape pressed down between each tube onto the foil-faced insulation board. Similarly, foil-faced tape should be used to hold the mat itself in place every four feet. See Figure 5.

2. Put three spacer blocks in place 12" apart every two feet. These blocks are made of 1 1/2" lengths of 1" EPDM hose. They are set in place between slightly spread tubes and held in place by the absorber cement (next step). See Figure 6.

3. Spray or brush the two-part absorber cement over the entire surface until the aluminum foil is completely blacked out. To insure a good bond the joint where the tubes and foil meet must be filled with adhesive. In mixing the two-part cement, directions on the can should be followed carefully.

4. At the side of the collector where the external plumbing connections are to be made, passageways for the connections should be cut through the perimeter strips and pipe nipples for the connections should be cut through the perimeter strips and pipe nipples extending through the perimeter wall should be installed. At this point in the construction process it is usually advantageous to hook up the sensor that measures the outlet temperature for the differential thermostat and any other valves or vents indicated. See Figure 7.

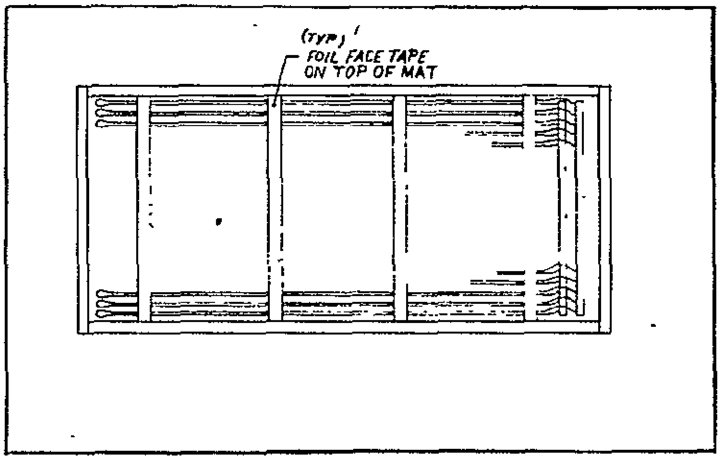


Figure 5

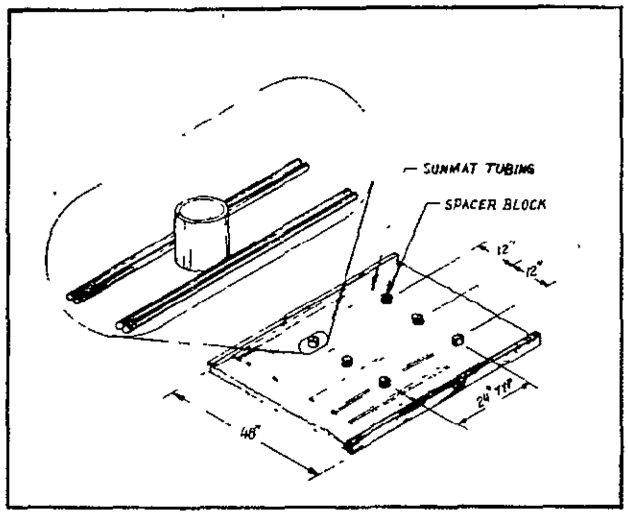


Figure 6

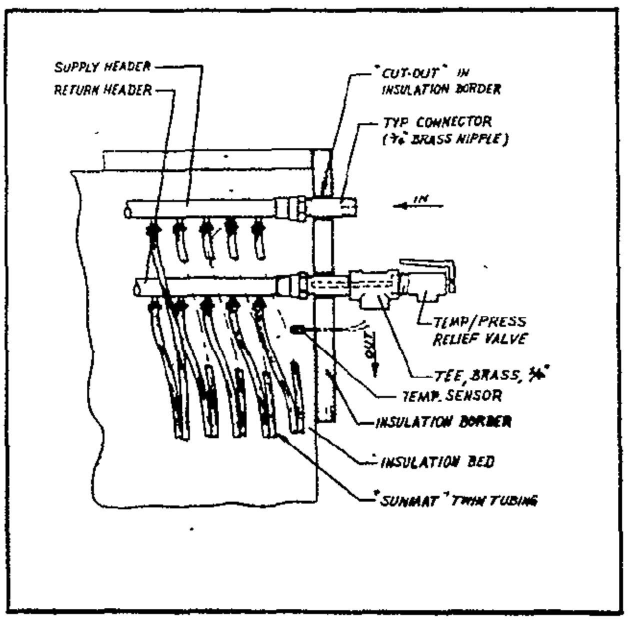


Figure 7

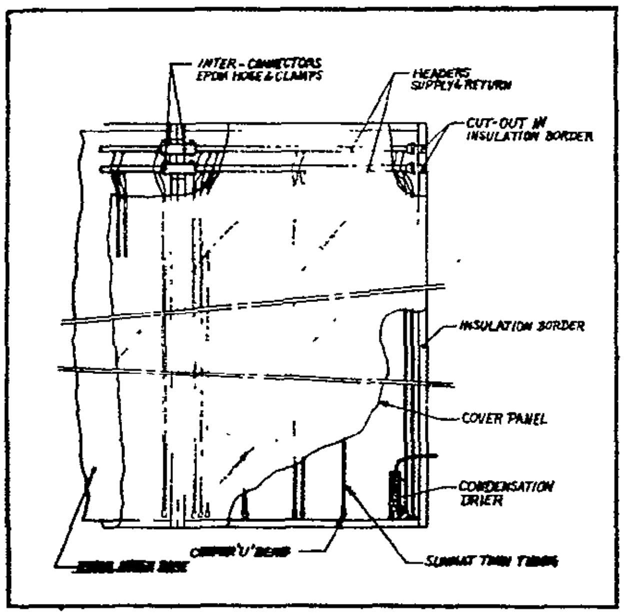


Figure 8

D. Dryer Tubes

1. Install one dryer tube for every 200 square feet of collector or fraction thereof. Dryer tubes are used to prevent the build-up of moisture condensation-under-the-collector-glazing. The dryer tube is installed along the outside perimeter by punching an outlet in the border strip with a screwdriver. See Figure 8.

E. Installing the Plastic Glazing

1. Apply a coat of contact cement to the top edge of the perimeter strip. Start from one end, then move to the sides and down the borders toward the opposite end, catching the spacer blocks as well. If the length of the collector is less than 12 feet, the contact cement can be applied in one step but if the length exceeds 12 feet, more than one step may be necessary since the cement dries quickly.

2. Place the end of the rolled up plastic glazing over the end of the collector coated first, and unroll the glazing. The glazing should be unrolled gradually, making sure that it is running square to the border. After it is completely unrolled, press it lightly against the border and spacer blocks to insure good bonding.

F. Waterproofing the Complete Collector

1. Waterproof the entire system by applying roofing mastic to all the exposed insulation, and to the 1" edge of the plastic glazing that overlaps the insulation board perimeter. Cement should be used liberally to make a seal around the header pipes and dryer tube where they come through the insulation board. Use masking tape on the glazing so as to make a straight edge between mastic and glazing.

IV. REPAIRS AND MAINTENANCE

A. General

1. No routine maintenance is required, but the collector should be checked at least annually for breakdowns in the system.

2. Rain should keep the collector cover relatively dirt-free. However, if dirt or dust accumulates, it may be necessary to hose and wash the cover. Normal wind and water gradually abrade the cover panel, and to insure optimum performance every five to seven years the panel must be spray-coated with Kal-Lac, a fast-drying liquid applied by roller, spray or brush.

3. Over time cracks may develop in the waterproofing, particularly in areas where the roofing mastic was put on too thin. These cracks can be easily repaired with fresh mastic.

4. Any leaks that may develop in the tubing system can be repaired with copper splicer tubes and Stimpson clamps from the repair kit. To make this type of repair a knife should be used to cut through the fiberglass border strips. After the cut is made, the cover can be lifted to expose the tubing. To repair the tubing the damaged piece should be cut out and a splicer tube put in its place and fastened with Stimpson clamps at either end. See Figure 11. Contact cement can then be used to cement the fiberglass back together. Finally a new coat of mastic should be applied to seal the collector.

5. Because of the small diameter of the SUNMAT tubing, capillary action prevents easy draining of the tubing. In the event the collector must be completely drained, air pressure must be used to force fluid out of the tubing grid.

6. Every several years flushing of the system may be advisable. Water run through the system at 40 PSI is generally adequate. Connections for flushing should be included at the time of installation.

7. Heat Transfer Fluids. Heat transfer fluids should be maintained in accordance with specifications provided by the manufacturer. The SUNMAT system is compatible with glycol anti-freezes. Contact CALMAC before using other anti-freezes.

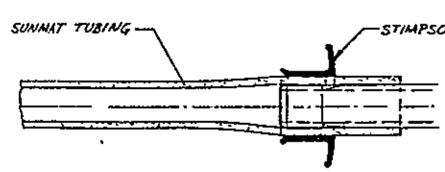
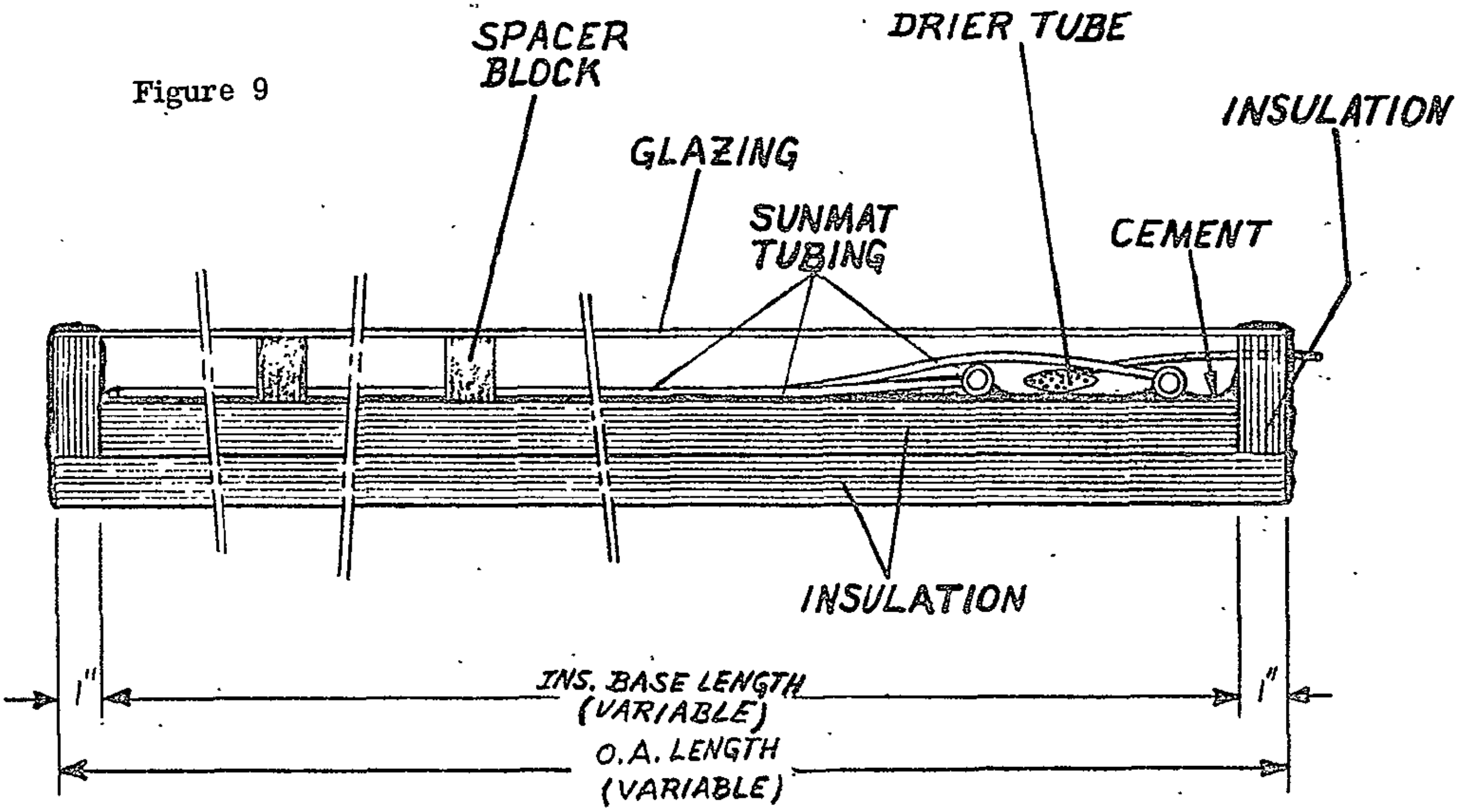


Figure 11

Figure 9



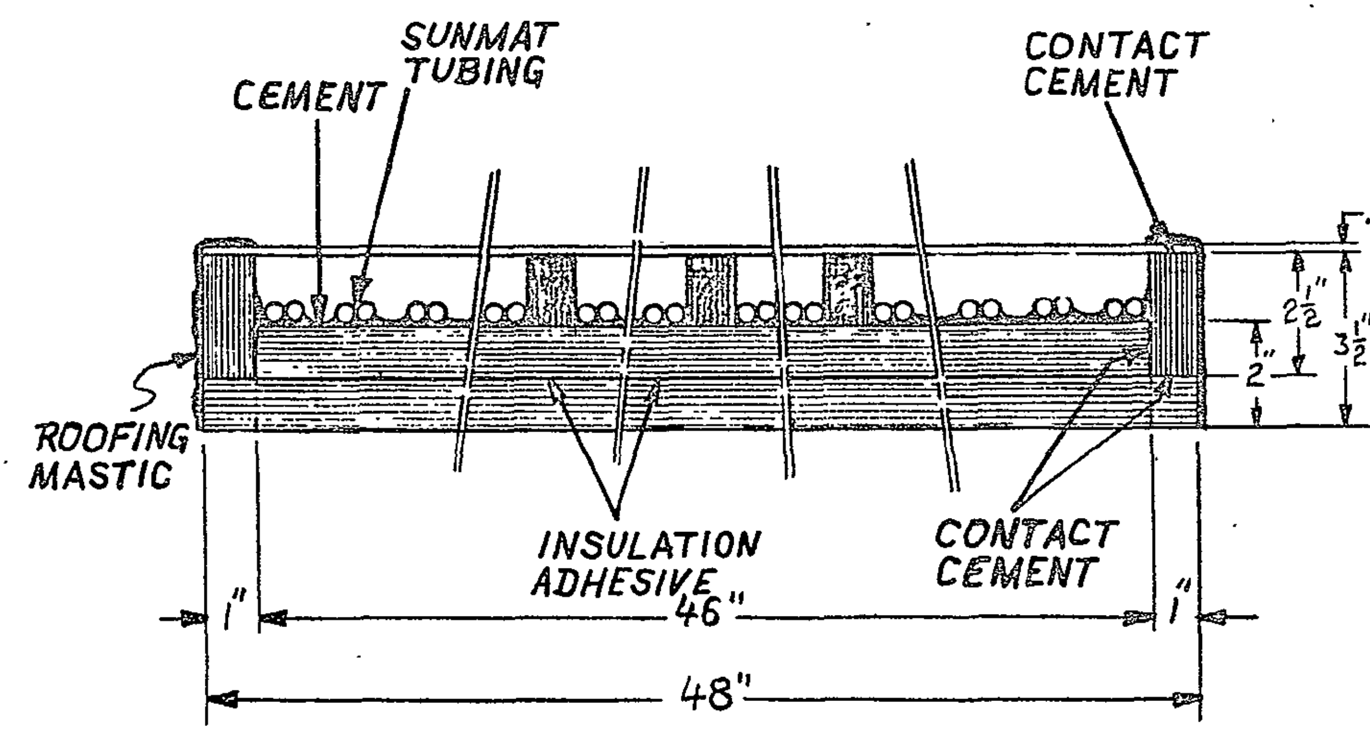


Figure 10

V. SPECIFICATIONS

PHYSICAL DATA:

Width: 4'
Length: Up to 50'
Depth: 3 1/2"
Weight (unfilled): 2.0 pounds/ft^2
Coolant Weight: .2 pounds/ft^2

MATERIALS:

Glazing: .025" guage fiberglass-reinforced polyester. 88% solar transmittance at 0°, 78% at 45°. Kalwall SUN-LITE Premium II or equivalent.

Absorber: 5/16" OD, 3/16" ID EPDM dual tubing spaced 1 1/2" on center bonded to insulation board with CAL-ZORB urethane cement. One gallon covers 40 square feet.

Headers: 3/4" x 42 1/2" type L copper pipe. External connections are 3/4" threaded pipe connections soldered to the pipe. Connections to the absorber tubing are 1/4" nipples soldered to the pipe every 1 3/8". Two headers per mat.

Desiccant: Silica gel in aluminum wire mesh tube. One dryer required for every 200 square feet of collector or fraction thereof.

Insulation: Fiberglass duct board, high temperature (350°F), three pounds per cubic foot density, foil-faced, 1" thick. Owens-Corning Fiberglass 703 or equivalent.

Adhesives: Contact cement used to bond cover panel and perimeter walls to insulation bed, 3M 1300 Rubber Adhesive or equivalent. One gallon for every 130 square feet of collector. Adhesive used to waterproof the collector, roofing mastic. Adhesive used to bond insulation together, Foster 85-15 Stic-Safe Adhesive.

Coolant: Water or mixture of glycol and water. .03 gallons per square foot.

OPERATING DATA:

Flow Rates: .018 GPM per square foot of mat, minimum of 2.0 GPM.
Pressure Drop: .16 PSI per foot of length of mat, water.
.2 PSI per foot of length of mat, 40% ethylene glycol at 100°F.
Temperature: Maximum operating temperature, 210°F.
Maximum allowable tubing temperature, 350°F.
Fluid Pressure: Maximum operating pressure, 20PSI. Tubing burst pressure, 80PSI.

$F_R U_L$: .86

$F_R(\tau\alpha)_n$: .67

COLLECTOR SIZING GUIDE

SOLAR ENERGY

Collector Sizing Guide For Solar Energy Systems

A. Sizing of Conventional vs. Solar Systems

Determining the optimum size for a solar collector is an economic decision as well as a technical one. In this respect the job of sizing a solar system is somewhat different from the job of sizing a conventional heating or air conditioning system. Conventional heating or air conditioning systems are sized by determining the capacity required to meet the peak demands of design conditions--since the equipment is the only source of heating and cooling and is expected to provide adequate performance at the extremes of expected conditions. Solar systems, on the other hand, operate in conjunction with backup systems, which take up the load under extreme conditions that the solar system cannot handle.

The sizing question is not "How much capacity is needed to handle 100% of the load?" as it is with conventional equipment, but rather two questions: "How much of the capacity should the solar system provide?" and "How big a system is required to provide that portion of the capacity?"

The first of these two questions is the key one and it is an economic one. Solar systems involve high initial capital costs and low operating costs, and the capital costs are paid for out of the energy costs saved every day the equipment is used. The optimum amount of solar capacity to install is therefore the amount that will recover the initial costs out of lowered operating costs as quickly as possible. From this standpoint excess solar capacity is uneconomic--excess capacity is capacity that is not being used, and capacity that is not being used, is not saving energy and paying for itself. As a result, optimally sized solar equipment generally should provide about 50% of the total annual energy requirements for most applications.

The methods described in this manual for sizing solar systems provide a rapid, practical means of estimating heating load requirements and the solar contribution to that heating requirement. Other, more sophisticated methods, some using computer analysis, are available and may be used, but the methods described here are accurate enough for most applications. The SUNMAT Collector efficiency data included in the Specifications section should be used when further analysis is indicated.

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B. Determining the Heating Load

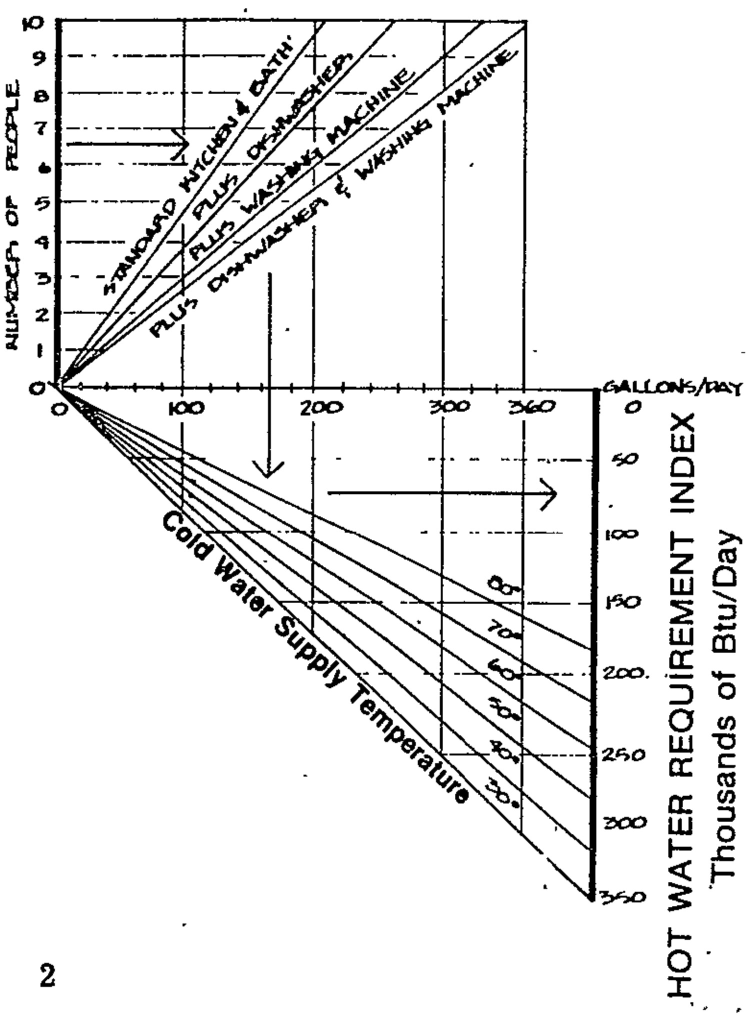
1. Determining the total heating requirement is the first step in sizing the solar system.

a. Domestic Hot Water. The amount of heat required to produce hot water for a home depends on the temperature of the incoming water, and the amount of water used.

Table A illustrates typical monthly temperatures of water in domestic supply mains and can be used as a guide in determining the incoming temperature. Local water suppliers can provide more accurate data for specific locations.

The U.S. Department of Commerce has compiled estimates of how much hot water an average household consumes in a variety of daily uses:

Clothes Washer (hot).......	21 GPD
Bath/Shower..............	15 GPD
Automatic Dishwasher	15 GPD
Hand Dishwashing	4 GPD
Food Preparations	3 GPD
Hand & Face Washing......	2 GPD



Month	HEATING REQUIREMENTS
January	95,000 BTU/Day
February	94,000
March	90,000
April	75,000
May	70,000
June	60,000
July	55,000
August	62,000
September	65,000
October	70,000
November	80,000
December	80,000

Figure 1-2

On average a family uses 20-25 gallons per person per day for bathing and cooking. To this must be added requirements for various appliances.

Use Figure 1-1 to estimate the domestic hot water heat requirements and fill in the estimates in Column M of Table B. Figure 1-2 provides an example for a family of five located in Boston.

b. Space Heating. The amount of energy required to heat a home can be calculated in the conventional manner or by examining old fuel bills. However, as a rule of thumb it is also possible to estimate the heating load as 8 BTUs per degree-day per square foot of building. This is what the heat loss should be for a solar-heated home. If it is higher than this, additional insulation should be provided.

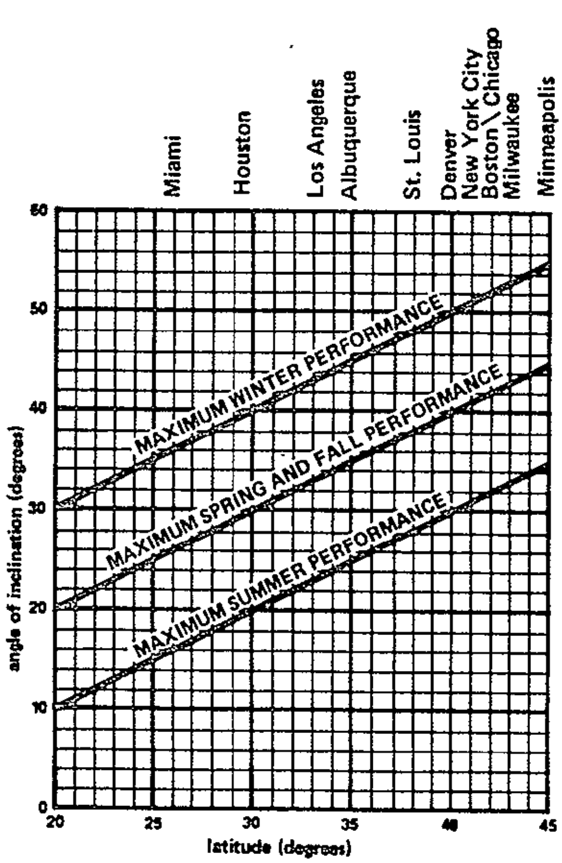
Complete Column L and M of Table C to determine the heating load on the building in question. Table D provides degree day estimates for all regions of the country.

C. Determining the Collector Size

1. The first step in sizing the collector is to determine the angle which the collector is to be tilted. The optimum tilt is that angle that spreads out the amount of sun that can be collected as evenly as possible over the entire period of intended use. In an application requiring year-round use, for example, this means an angle which allows full collection of the sun's weaker rays in the winter but misses some of the stronger rays in the summer. Figure 1-3 can be used as a guide in determining the optimum collector angle.

The collectors should also be installed facing as directly south as possible, although variations of up to 15^o will not have a significant impact on performance.

2. The next step in this process is to calculate the amount of energy that one square foot of collector can provide on an average day in each of the twelve months of the year. To do this complete Section I of Table B for Hot Water Heating and Table C for Space Heating.



OPTIMUM COLLECTOR ANGLES

Figure 1-3

Use Tables E, F and G to fill in the necessary data on tilt factor, horizontal insolation, and average temperature. The Average Daytime Air Temperature is generally estimated at six degrees above the 24-hour average temperature. Then proceed to carry out the calculations necessary to complete Section II of the tables.

3. The last step in sizing the solar system involves determining the collector area required to meet the desired portion of the total annual load.

a. Domestic Hot Water. The solar system should be sized to provide 50 to 60% of the energy requirements for a domestic hot water system. To make a preliminary estimate of the amount of collector area required, divide the total heating requirement in the month of June by the amount of energy collected by one square foot of collector in June. Then use this amount, which is the area required to provide 100% of the heat in June, as the estimate of the optimum size.

Then proceed to calculate how much energy the system will provide in the other 11 months by multiplying the amount of energy one square foot will collect by the number of square feet chosen.

To determine the percentage of the annual hot water heating requirement the solar system will provide, amounts in excess of the amounts needed must be lopped off. So enter in Column N, Usable Solar Energy, the lower of Columns L and M.

Add up the total annual heating requirement (Column M) and the total Usable Solar Energy (Column L) and divide in order to determine the percentage of total requirements provided by solar. If the percentage is not between 50 and 60% adjust the collector area and redo the calculations.

b. Space Heating. In a space heating application the economic size of the collector system is an area capable of providing roughly 40 to 50% of the total requirement. The method of determining the percentage of heat provided by the solar system is identical to the method used for domestic hot water heating, except that the initial estimate is made by dividing the total heating requirement in March by the amount of energy collected by one square foot of collector in March.

TABLE A

Source and Monthly Temperature in °F at that Source for Cold Water Supply in 14 Cities

		J	F	M	A	M	J	J	A	S	O	N	D
Albuquerque	W	72	72	72	72	72	72	72	72	72	72	72	72
Boston	Re	32	36	39	52	58	71	74	67	60	56	48	45
Chicago	L	32	32	34	42	51	57	65	67	62	57	45	35
Denver		39	40	43	49	55	60	63	64	63	56	45	37
Ft Worth	L	56	49	57	70	75	81	79	83	81	72	56	46
Las Vegas	W	73	73	73	73	73	73	73	73	73	73	73	73
Los Angeles	Ri W	50	50	54	63	68	73	74	76	75	69	61	55
Miami	W	70	70	70	70	70	70	70	70	70	70	70	70
Nashville	Ri	46	46	53	66	63	69	71	75	75	71	58	53
New York C	W	36	35	36	39	47	54	58	60	61	57	48	45
Phoenix	Ri Re W	48	48	50	52	57	59	63	75	79	69	59	54
Salt Lake C	W C	35	37	38	41	43	47	53	52	48	43	38	37
Seattle	Ri	39	37	43	45	48	57	60	68	66	57	48	43
Washington	Ri	42	42	52	56	63	67	67	78	79	68	55	46

Source Data from Handbook of Air Conditioning System Design p 5-41 through 5 46, McGraw Hill Book Company New York (1965). Abbreviations C-Creek, L-Lake, Re-Reservoir, Ri-River, W-Well

TABLE H

G	H
1.00	1.00
.99	.78
.98	.73
.97	.67
.96	.63
.95	.60
.94	.57
.93	.53
.92	.51
.91	.48
.90	.46
.89	.43
.88	.42
.87	.39
.86	.37
.85	.36
.84	.34
.83	.33
.82	.31
.81	.30
.80	.29
.79	.27
.78	.26
.77	.25
.76	.24
.75	.23
.74	.22
.73	.21
.72	.20
.71	.19
.70	.18

TABLE B

DOMESTIC HOT WATER SYSTEM SIZING

	Section I				Section II						Section III			
	A Average Air Temperature	B Inlet Water Temperature	C Horizontal Insolation	D Collector Tilt Factor	E Insolation on Collector = C x D	F Absorbed Heat = E x .67	G $\Delta T = \frac{140°+B}{2} - A$	H Heat Loss Parameter = 1-2.6 x G/E	I Heat Loss Factor From Table H	J Heat Collected = I x F	K Collector Area	L Available Monthly Solar Heat = J x K x 30	M Heating Load From Table	N Usable Solar Heat
JANUARY														
FEBRUARY														
MARCH														
APRIL														
MAY														
JUNE														
JULY														
AUGUST														
SEPTEMBER														
OCTOBER														
NOVEMBER														
DECEMBER														

TABLE C

SPACE HEATING
SYSTEM SIZING

	Section I				Section II					Section III				
	A	B	C	D	E	F	G	H	I	J	K	L	M	N
	Average Air Temperature	Horizontal Insolation	Collector Tilt Factor	Insolation On Collector	Absorbed Heat = D x .67	ΔT = 110°-A	Heat Loss Parameter = 1 - 2.6xF/D	Heat Loss Factor From Table H	Heat Collected = H x E	Collector Area	Available Monthly Solar Heat = I x J x 30	Degree Days Per Month	Total Load = L x 7 x building area	Usable Solar Heat
JANUARY														
FEBRUARY														
MARCH														
APRIL														
MAY														
JUNE														
JULY														
AUGUST														
SEPTEMBER														
OCTOBER														
NOVEMBER														
DECEMBER														
TOTAL														

TABLE E
COLLECTOR TILT FACTORS

	Degrees Latitude	L - 10	L	L + 10	L + 20	Vertical
January 21	24	1 22	1 34	1.42	1.45	1.09
	32	1 43	1 56	1.64	1.68	1 38
	40	1.75	1.9l	2.01	2.05	1.82
	48	2.27	2.47	2 59	2 64	2 47
	56	3.31	3.58	3 75	3.81	3.70
	64	5.96	6.44	6.71	6.8	6.76
February 21	24	1.14	1.20	1.22	1.21	0.75
	32	1 27	1.33	1.36	1.35	0.05
	40	1.46	1.53	1.56	1.54	1.22
	48	1.74	1.83	1.87	1.83	1 59
	56	2.22	2.32	2.42	2.32	2.16
	64	3.08	3.22	3.26	3.21	3.13
March 21	24	1.07	1.08	1 06	1.01	0.45
	32	1.14	1.15	1.13	1.08	0.61
	40	1.25	1 26	1.23	1.17	0 80
	48	1 19	1.20	1.18	1.12	0.88
	56	1.63	1.64	1.61	1.53	1.34
	64	1.99	2.01	1.96	1.86	1.78
April 21	24	1 00	0.98	0.91	0.82	0.20
	32	1 00	0.96	0.90	0 81	0.31
	40	1.06	1.02	0 95	0 86	0.45
	48	1.12	1.08	1 00	0 93	0.60
	56	1.21	1.16	1 08	0.97	0.77
	64	1.69	1.27	1 18	1.06	0.97
May 21	24	0.96	0 89	0 81	0.70	0.10
	32	0 96	0.89	0.81	0.70	0.10
	32	0.95	0.88	0.80	0.69	0.18
	40	0.96	0 89	0.80	0.69	0.28
	48	0.97	0.90	0.81	0.70	0.40
	56	1.00	0.92	0.83	0.71	0.51
	64	1.03	0.95	0.85	0 73	0.64
June 21	24	0.94	0.87	0.77	0.66	0.08
	32	0.92	0 85	0 76	0.64	0.14
	40	0.92	0.84	0.75	0 63	0.23
	48	0.92	0.92	0.74	0.63	0.33
	56	0.93	0.85	0.75	0.63	0.44
	64	0.94	0.85	0.75	0 63	0.55
July 21	24	0.95	0.89	0.81	0.70	0.10
	32	0.95	0.88	0.79	0.69	0.18
	40	0.95	0.95	0.79	0.68	0.28
	48	0.96	0 89	0.80	0.68	0 39
	56	0.99	0.91	0.81	0.69	0.50
	64	1 01	0.93	0.83	0.71	0.62
August 21	24	1.00	0.96	0.98	0.81	0 20
	32	1.02	0 98	0.91	0.82	0.31
	40	1.05	1.01	0.94	0.84	0 44
	48	1.10	1 05	0.98	0.88	0 58
	56	1.18	1.12	1.04	0.93	0 74
	64	1.28	0 61	1.13	1.01	0 92
September 21	24	1.11	1.08	1.06	1.01	0.45
	32	1 14	1.15	1.12	1.07	0.61
	40	1.24	1 25	1.22	1.16	0.79
	48	1.38	1.39	1.36	1.29	1.02
	56	1.60	1.61	1.57	1.49	1.31
	64	1.93	2.17	1.90	1.80	1.72
October 21	24	1.14	1.20	1 23	1.22	0 75
	32	1.27	1.33	1 36	1.35	0 96
	40	1.46	1.53	1.56	1.54	1.23
	48	1.74	1.82	1.85	1.83	1.59
	56	2.20	2.31	2.34	2.31	2 15
	64	3.04	3.17	3.22	3.17	3.09
November 21	24	1.22	1.33	1.41	1.44	1.07
	32	1.42	1.55	1.63	1.66	1.36
	40	1.74	1 89	1.99	2.03	1.79
	48	2.24	2 43	2.55	2.59	2.42
	56	3.22	3.47	3.63	3.68	3.58
	64	5.78	6.22	6.48	6.57	6.52
December 21	24	1.26	1.40	1.50	1.55	1.23
	32	1 50	1.66	1.77	1.84	1.58
	40	1.89	2.09	2.23	2.30	2.10
	48	2 55	2.80	2.97	3.06	2.92
	56	3.95	4.32	4.56	4.68	4.60
	64	10 0	11.0	12.0	12.0	12.0

TABLE D

Average Monthly and Yearly Degree Days for Cities in the United States and Canada (Base 65 F) (Continued)

State	Station		Avg Winter Temp[d]	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr.	May	June	Yearly Total
Mich	Alpena	A	29.7	68	105	273	580	912	1268	1404	1299	1218	777	446	156	8506
	Detroit (City)	A	37.2	0	0	87	360	738	1088	1181	1058	936	522	220	42	6232
	Detroit (Wayne)	A	37.1	0	0	96	353	738	1088	1194	1061	933	534	239	57	6293
	Detroit (Willow Run)	A	37.2	0	0	90	357	750	1104	1190	1053	921	519	229	45	6258
	Escanaba	C	29.6	59	87	243	539	924	1293	1445	1296	1203	777	456	159	8481
	Flint	A	33.1	16	40	159	465	843	1212	1330	1198	1066	639	319	90	7377
	Grand Rapids	A	34.9	9	28	135	434	804	1147	1259	1134	1011	579	279	75	6894
	Lansing	A	34.8	6	22	138	431	813	1163	1262	1142	1011	579	273	69	6909
	Marquette	C	30.2	59	81	240	527	936	1268	1411	1268	1187	771	468	177	8393
	Muskegon	A	36.0	12	28	120	400	762	1088	1209	1100	995	594	310	78	6696
	Sault Ste Marie	A	27.7	96	105	279	580	951	1367	1525	1380	1277	810	477	201	9048
Minn	Duluth	A	23.4	71	109	330	632	1131	1581	1745	1518	1355	840	490	198	10000
	Minneapolis	A	28.3	22	31	189	505	1014	1454	1631	1380	1166	621	288	81	8382
	Rochester	A	28.8	25	34	186	474	1005	1438	1593	1366	1150	630	301	93	8295
Miss	Jackson	A	55.7	0	0	0	65	315	502	546	414	310	87	0	0	2239
	Meridian	A	55.4	0	0	0	81	339	518	543	417	310	81	0	0	2289
	Vicksburg	C	56.9	0	0	0	53	279	462	512	384	282	69	0	0	2041
Mo	Columbia	A	42.3	0	0	54	251	651	967	1076	874	716	324	121	12	5046
	Kansas City	A	43.9	0	0	39	220	612	905	1032	818	682	294	109	0	4711
	St Joseph	A	40.3	0	6	60	285	708	1039	1172	949	769	348	133	15	5484
	St Louis	A	43.1	0	0	60	251	627	936	1026	848	704	312	121	15	4900
	St Louis	C	44.8	0	0	36	202	576	884	977	801	651	270	87	0	4484
	Springfield	A	44.5	0	0	45	223	600	877	973	781	660	291	105	6	4900
Mont.	Billings	A	34.5	6	15	186	487	897	1135	1296	1100	970	570	285	102	7049
	Glasgow	A	26.4	31	47	270	608	1104	1466	1711	1439	1187	648	335	150	8996
	Great Falls	A	32.8	28	53	258	543	921	1169	1349	1154	1063	642	384	186	7750
	Havre	A	28.1	28	53	306	595	1065	1367	1584	1364	1181	657	338	162	8700
	Havre	C	29.8	19	37	252	539	1014	1321	1528	1305	1116	612	304	135	8182
	Helena	A	31.1	31	59	294	601	1002	1265	1438	1170	1042	651	381	195	8129
	Kalispell	A	31.4	50	99	321	654	1020	1240	1401	1134	1029	639	397	207	8191
	Miles City	A	31.2	6	6	174	502	972	1296	1504	1252	1057	579	276	99	7723
	Missoula	A	31.5	34	74	303	651	1035	1287	1420	1120	970	621	391	219	8125
Neb	Grand Island	A	36.0	0	6	108	381	834	1172	1314	1089	908	462	211	45	6530
	Lincoln	C	38.8	0	6	75	301	726	1066	1237	1016	834	402	171	30	5864
	Norfolk	A	34.0	9	0	111	397	873	1234	1414	1179	983	498	233	48	6979
	North Platte	A	35.5	0	6	123	440	885	1166	1271	1039	930	519	248	57	6684
	Omaha	A	35.6	0	12	105	357	828	1175	1355	1126	939	465	208	42	6612
	Scottsbluff	A	35.9	0	0	138	459	876	1128	1231	1008	921	552	285	75	6673
	Valentine	A	32.6	9	12	165	493	942	1237	1395	1176	1045	579	288	84	7425
Nev	Elko	A	34.0	9	34	225	561	924	1197	1314	1036	911	621	409	192	7433
	Ely	A	33.1	28	43	234	592	939	1184	1308	1075	977	672	456	225	7733
	Las Vegas	A	53.5	0	0	0	78	387	617	688	487	335	111	6	0	2709
	Reno	A	39.3	43	87	204	490	801	1026	1073	823	729	510	357	189	6332
	Winnemucca	A	36.7	0	34	210	536	876	1091	1172	916	837	573	363	153	6761
N H	Concord	A	33.0	6	50	177	505	822	1240	1358	1184	1032	636	298	75	7383
	Mt Washington Obsv		15.2	493	536	720	1057	1341	1742	1820	1663	1652	1260	930	603	13817
N J	Atlantic City	A	43.2	0	0	39	251	549	880	936	848	741	420	133	15	4812
	Newark	A	42.8	0	0	30	248	573	921	983	876	729	381	118	0	4589
	Trenton	C	42.4	0	0	57	264	576	924	989	885	753	399	121	12	4980
N M.	Albuquerque	A	45.0	0	0	12	229	642	868	930	703	595	288	81	0	4348
	Clayton	A	42.0	0	6	66	310	699	899	986	812	747	429	183	21	5158
	Raton	A	38.1	9	28	126	431	825	1048	1116	904	834	543	301	63	6228
	Roswell	A	47.5	0	0	18	202	573	806	840	641	481	201	31	0	3793
	Silver City	A	48.0	0	0	6	183	525	729	791	605	518	261	87	0	3705
N Y	Albany	A	34.6	0	19	138	440	777	1194	1311	1156	992	564	239	45	6875
	Albany	C	37.2	0	9	102	375	699	1104	1218	1072	908	498	186	30	6201
	Binghamton	A	33.9	22	65	201	471	810	1184	1277	1154	1045	645	313	99	7286
	Binghamton	C	36.6	0	28	141	406	732	1107	1190	108	949	543	229	45	6451
	Buffalo	A	34.5	19	37	141	440	777	1156	1256	1145	1039	645	329	78	7062
	New York (Cent Park)	C	42.8	0	0	30	233	540	902	986	885	760	408	118	9	4871
	New York (La Guardia)	A	43.1	0	0	27	223	528	887	973	879	750	414	124	6	4811

Average Monthly and Yearly Degree Days for Cities in the United States and Canada (Base 65 F) (Continued)

State	Station		Avg Winter Temp[d]	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	Yearly Total
	New York (Kennedy)	A	41.4	0	0	36	248	564	933	1029	935	815	480	167	12	5219
	Rochester	A	35.4	9	31	126	415	747	1125	1234	1123	1014	597	279	48	6748
	Schenectady	C	35.4	0	22	123	422	756	1159	1283	1131	970	543	211	30	6650
	Syracuse	A	35.2	6	28	132	415	744	1153	1271	1140	1004	570	248	45	6756
N C.	Asheville	C	46.7	0	0	48	245	555	775	784	683	592	273	87	0	4042
	Cape Hatteras		53.3	0	0	0	78	273	521	580	518	440	177	25	0	2612
	Charlotte	A	50.4	0	0	6	124	438	691	691	582	481	156	22	0	3191
	Greensboro	A	47.5	0	0	33	192	513	778	784	672	552	234	47	0	3805
	Raleigh	A	49.4	0	0	21	164	450	716	725	616	487	180	34	0	3393
	Wilmington	A	54.6	0	0	0	74	291	521	546	462	357	96	0	0	2347
	Winston Salem	A	48.4	0	0	21	171	483	747	753	652	524	207	37	0	3595
N D.	Bismarck	A	26.6	34	28	222	577	1083	1463	1708	1442	1203	645	329	117	8851
	Devils Lake	C	22.4	40	53	273	642	1191	1634	1872	1579	1345	753	381	138	9901
	Fargo	A	24.8	28	37	219	574	1107	1569	1789	1520	1262	690	332	99	9226
	Williston	A	25.2	31	43	261	601	1122	1513	1758	1473	1262	681	357	141	9243
Ohio	Akron Canton	A	38.1	0	9	96	381	726	1070	1138	1016	871	489	202	39	6037
	Cincinnati	C	45.1	0	0	39	208	558	862	915	790	642	294	96	6	4410
	Cleveland	A	37.2	9	25	105	384	738	1088	1159	1047	918	552	260	66	6351
	Columbus	A	39.7	0	6	84	347	714	1039	1088	949	809	426	171	27	5660
	Columbus	C	41.5	0	0	57	285	651	977	1032	902	760	396	136	15	5211
	Dayton	A	39.8	0	6	78	310	696	1045	1097	955	809	429	167	30	5622
	Mansfield	A	36.9	9	22	114	397	768	1110	1169	1042	924	543	245	60	6403
	Sandusky	C	39.1	0	6	66	313	684	1032	1107	991	868	495	198	36	5796
	Toledo	A	36.4	0	16	117	406	792	1138	1200	1056	924	543	242	60	6494
	Youngstown	A	36.8	6	19	120	412	771	1104	1169	1047	921	540	248	60	6417
Okla	Oklahoma City	A	48.3	0	0	15	164	498	766	868	664	527	189	34	0	3725
	Tulsa	A	47.7	0	0	18	158	522	787	893	683	539	213	47	0	3860
Ore	Astoria	A	45.6	146	130	210	375	561	679	753	622	636	480	363	231	5186
	Burns	C	35.9	12	37	210	515	867	1113	1246	988	856	570	366	177	6957
	Eugene	A	45.6	34	34	129	366	585	719	803	627	589	426	279	135	4726
	Meacham	A	34.2	84	124	288	580	918	1091	1209	1005	983	726	527	339	7874
	Medford	A	43.2	0	0	78	372	678	871	918	697	642	432	242	78	5008
	Pendleton	A	42.6	0	0	111	350	711	884	1017	773	617	396	205	63	5127
	Portland	A	45.6	25	28	114	335	597	735	825	644	586	396	245	105	4635
	Portland	C	47.4	12	16	75	267	534	679	769	594	536	351	198	78	4109
	Roseburg	A	46.3	22	16	105	329	567	713	766	608	570	405	267	123	4491
	Salem	A	45.4	37	31	111	338	594	729	822	647	611	417	273	144	4754
Pa	Allentown	A	38.9	0	0	90	353	693	1045	1116	1002	849	471	167	24	5810
	Erie	A	36.8	0	25	102	391	714	1063	1169	1081	973	585	288	60	6451
	Harrisburg	A	41.2	0	0	63	298	648	992	1045	907	766	396	124	12	5251
	Philadelphia	A	41.8	0	0	60	297	620	965	1016	889	747	392	118	40	5144
	Philadelphia	C	44.5	0	0	30	205	513	856	924	823	691	351	93	0	4486
	Pittsburgh	A	38.4	0	9	105	375	726	1063	1119	1002	874	480	195	39	5987
	Pittsburgh	C	42.2	0	0	60	291	615	930	983	885	763	390	124	12	5053
	Reading	C	42.4	0	0	54	257	597	939	1001	885	735	372	105	0	4945
	Scranton	A	37.2	0	19	132	434	762	1104	1156	1028	893	498	195	33	6254
	Williamsport	A	38.5	0	9	111	375	717	1073	1122	1002	856	468	177	24	5934
R I	Block Island	A	40.1	0	16	78	307	594	902	1020	955	877	612	344	99	5804
	Providence	A	38.8	0	16	96	372	660	1023	1110	988	868	534	236	51	5954
S C	Charleston	A	56.4	0	0	0	59	282	471	487	389	291	54	0	0	2033
	Charleston	C	57.9	0	0	0	34	210	425	443	367	273	42	0	0	1794
	Columbia	A	54.0	0	0	0	84	345	577	570	470	357	81	0	0	2484
	Florence	A	54.5	0	0	0	78	315	552	552	459	347	84	0	0	2387
	Greenville Spartenburg	A	51.6	0	0	6	121	399	651	660	546	446	132	19	0	2980
S D	Huron	A	28.8	9	12	165	508	1014	1432	1628	1355	1125	600	288	87	8223
	Rapid City	A	33.4	22	12	165	481	897	1172	1333	1145	1051	615	326	126	7345
	Sioux Falls	A	30.6	19	25	168	462	972	1361	1544	1285	1082	573	270	78	7839
Tenn.	Bristol	A	46.2	0	0	51	236	573	828	828	700	598	261	68	0	4143
	Chattanooga	A	50.3	0	0	18	143	468	698	722	577	453	150	25	0	3254
	Knoxville	A	49.2	0	0	30	171	489	725	732	613	493	198	43	0	3494
	Memphis	A	50.5	0	0	18	130	447	698	729	585	456	147	22	0	3232

Average Monthly and Yearly Degree Days for Cities in the United States and Canada[a,b] (Base 65 F)

State	Station		Avg Winter Temp[d]	July	Aug	Sept	Oct	Nov	Dec	Jan.	Feb	Mar	Apr	May	June	Yearly Total
Ala	Birmingham	A	54.2	0	0	6	93	363	555	592	462	363	108	9	0	2551
	Huntsville	A	51.3	0	0	12	127	426	663	694	557	434	138	19	0	3070
	Mobile	A	59.9	0	0	0	22	213	357	415	300	211	42	0	0	1560
	Montgomery	A	55.4	0	0	0	68	330	527	543	417	316	90	0	0	2291
Alaska	Anchorage	A	23.0	245	291	516	930	1284	1572	1631	1316	1293	879	592	315	10864
	Fairbanks	A	6.7	171	332	642	1203	1833	2254	2359	1901	1739	1068	555	222	14279
	Juneau	A	32.1	301	338	483	725	921	1135	1237	1070	1073	810	601	381	9075
	Nome	A	13.1	481	496	693	1094	1455	1820	1879	1666	1770	1314	930	573	14171
Ariz	Flagstaff	A	35.6	46	68	201	558	867	1073	1169	991	911	651	437	180	7152
	Phoenix	A	58.5	0	0	0	22	234	415	474	328	217	75	0	0	1765
	Tucson	A	58.1	0	0	0	25	231	406	471	344	242	75	6	0	1800
	Winslow	A	43.0	0	0	6	245	711	1008	1054	770	601	291	96	0	4782
	Yuma	A	64.2	0	0	0	0	108	264	307	190	90	15	0	0	974
Ark	Fort Smith	A	50.3	0	0	12	127	450	704	781	596	456	144	22	0	3292
	Little Rock	A	50.5	0	0	9	127	465	716	756	577	434	126	9	0	3219
	Texarkana	A	54.2	0	0	0	78	345	561	626	468	350	105	0	0	2533
Calif	Bakersfield	A	55.4	0	0	0	37	282	502	546	364	267	105	19	0	2122
	Bishop	A	46.0	0	0	48	260	576	797	874	680	555	306	143	36	4275
	Blue Canyon	A	42.2	28	37	108	347	594	781	896	795	806	597	412	195	5596
	Burbank	A	58.6	0	0	6	43	177	301	366	277	239	138	81	18	1646
	Eureka	C	49.9	270	257	258	329	414	499	546	470	505	438	372	285	4643
	Fresno	A	53.3	0	0	0	84	354	577	605	426	335	162	62	6	2611
	Long Beach	A	57.8	0	0	9	47	171	316	397	311	264	171	93	24	1803
	Los Angeles	A	57.4	28	28	42	78	180	291	372	302	288	219	158	81	2061
	Los Angeles	C	60.3	0	0	6	31	132	229	310	230	202	123	68	18	1349
	Mt Shasta	C	41.2	25	34	123	406	696	902	983	784	738	525	347	159	5722
	Oakland	A	53.5	53	50	45	127	309	481	527	400	353	255	180	90	2870
	Red Bluff	A	53.8	0	0	0	53	318	555	605	428	341	168	47	0	2515
	Sacramento	A	53.9	0	0	0	56	321	546	583	414	332	178	72	0	2502
	Sacramento	C	54.4	0	0	0	62	312	533	561	392	310	173	-	0	2419
	Sandberg	C	46.8	0	0	30	202	480	691	778	661	620	426	264	57	4209
	San Diego	A	59.5	9	0	21	43	135	236	298	235	214	135	90	42	1458
	San Francisco	A	53.4	81	78	60	143	306	462	508	395	363	279	214	126	3015
	San Francisco	C	55.1	192	174	102	118	231	388	443	336	319	279	239	180	3001
	Santa Maria	A	54.3	99	93	96	146	270	391	459	370	363	282	233	165	2967
Colo	Alamosa	A	29.7	65	99	279	639	1065	1420	1476	1162	1020	696	440	168	8529
	Colorado Springs	A	37.3	9	25	132	456	825	1032	1128	938	893	582	319	84	6423
	Denver	A	37.6	6	9	117	428	819	1035	1132	938	887	558	288	66	6283
	Denver	C	40.8	0	0	90	366	714	905	1004	851	800	492	254	48	5524
	Grand Junction	A	39.3	0	0	30	313	786	1113	1209	907	729	387	146	21	5641
	Pueblo	A	40.4	0	0	54	326	750	986	1085	871	772	429	174	15	5462
Conn	Bridgeport	A	39.9	0	0	66	307	615	986	1079	966	853	510	208	27	5617
	Hartford	A	37.3	0	12	117	394	714	1101	1190	1042	908	519	205	33	6235
	New Haven	A	39.0	0	12	87	347	648	1011	1097	991	871	543	245	45	5897
Del	Wilmington	A	42.5	0	0	51	270	588	927	980	874	735	387	112	6	4930
DC	Washington	A	45.7	0	0	33	217	519	834	871	762	626	288	74	0	4224
Fla.	Apalachicola	C	61.2	0	0	0	16	153	319	347	260	180	33	0	0	1308
	Daytona Beach	A	64.5	0	0	0	0	75	211	248	190	140	15	0	0	879
	Fort Myers	A	68.6	0	0	0	0	24	109	146	101	62	0	0	0	442
	Jacksonville	A	61.9	0	0	0	12	144	310	332	246	174	21	0	0	1239
	Key West	A	73.1	0	0	0	0	0	28	40	31	9	0	0	0	108
	Lakeland	C	66.7	0	0	0	0	57	164	195	146	99	0	0	0	661
	Miami	A	71.1	0	0	0	0	0	65	74	56	19	0	0	0	214

[a] Data for United States cities from a publication of the United States Weather Bureau *Monthly Normals of Temperature, Precipitation and Heating Degree Days*, 1962, are for the period 1931 to 1960 inclusive. These data also include information from the 1963 revisions to this publication where available.
[b] Data for airport stations, A, and city stations, C, are both given where available.
[c] Data for Canadian cities were computed by the Climatology Division, Department of Transport from normal monthly mean temperatures, and the monthly values of heating degree days data were obtained using the National Research Council computer and a method devised by H. C. S. Thom of the United States Weather Bureau. The heating degree days are based on the period from 1931 to 1960.
[d] For period October to April inclusive.

Average Monthly and Yearly Degree-Days for Cities in the United States and Canada (Base 65 F) (Continued)

State	Station		Avg Winter Temp[d]	July	Aug	Sept	Oct.	Nov.	Dec	Jan	Feb	Mar	Apr	May	June	Yearly Total
Fla (Cont'd)	Miami Beach	C	72.5	0	0	0	0	0	40	56	30	[illegible]	0	0	0	141
	Orlando	A	65.7	0	0	0	0	72	198	220	165	105	6	0	0	766
	Pensacola	A	60.4	0	0	0	19	195	353	400	277	183	36	0	0	1463
	Tallahassee	A	60.1	0	0	0	28	198	360	375	286	202	36	0	0	1485
	Tampa	A	66.4	0	0	0	0	60	171	202	148	102	0	0	0	683
	West Palm Beach	A	68.4	0	0	0	0	6	65	87	64	31	0	0	0	253
Ga	Athens	A	51.8	0	0	12	115	405	632	642	529	[illegible]	141	22	0	2929
	Atlanta	A	51.7	0	0	18	124	417	648	636	518	428	147	25	0	2961
	Augusta	A	54.5	0	0	0	78	333	552	549	445	350	90	0	0	2397
	Columbus	A	54.8	0	0	0	87	333	543	552	434	338	96	0	0	2383
	Macon	A	56.2	0	0	0	71	297	502	505	403	295	63	0	0	2136
	Rome	A	49.9	0	0	24	161	474	701	710	577	468	177	34	0	3326
	Savannah	A	57.8	0	0	0	47	246	437	437	353	254	45	0	0	1819
	Thomasville	C	60.0	0	0	0	25	198	366	394	305	208	33	0	0	1529
Hawaii	Lihue	A	72.7	0	0	0	0	0	0	0	0	0	0	0	0	0
	Honolulu	A	74.2	0	0	0	0	0	0	0	0	0	0	0	0	0
	Hilo	A	71.9	0	0	0	0	0	0	0	0	0	0	0	0	0
Idaho	Boise	A	39.7	0	0	132	415	792	1017	1113	854	722	438	245	81	5809
	Lewiston	A	41.0	0	0	123	403	756	933	1063	815	694	426	239	90	5542
	Pocatello	A	34.8	0	0	172	493	900	1166	1324	1058	905	555	319	141	7033
Ill	Cairo	C	47.9	0	0	36	164	513	791	856	680	539	195	47	0	3821
	Chicago (O'Hare)	A	35.8	0	12	117	381	807	1166	1265	1086	939	534	260	72	6639
	Chicago (Midway)	A	37.5	0	0	81	326	753	1113	1209	1044	890	480	211	48	6155
	Chicago	C	38.9	0	0	66	279	705	1051	1150	1000	868	489	226	48	5882
	Moline	A	36.4	0	9	99	335	774	1181	1314	1100	918	450	189	39	6408
	Peoria	A	38.1	0	6	87	326	759	1113	1218	1025	849	426	183	33	6025
	Rockford	A	34.8	6	9	114	400	837	1221	1333	1137	961	516	236	60	6830
	Springfield	A	40.6	0	0	72	291	696	1023	1135	935	769	354	136	18	5429
Ind	Evansville	A	45.0	0	0	66	220	606	896	955	767	620	237	68	0	4435
	Fort Wayne	A	37.3	0	9	105	378	783	1135	1178	1028	890	471	189	39	6205
	Indianapolis	A	39.6	0	0	90	316	723	1051	1113	949	809	432	177	39	5699
	South Bend	A	36.6	0	6	111	372	777	1125	1221	1070	933	525	239	60	6439
Iowa	Burlington	A	37.6	0	0	93	322	768	1135	1259	1042	859	426	177	33	6114
	Des Moines	A	35.5	0	6	96	363	828	1225	1370	1137	915	438	180	30	6588
	Dubuque	A	32.7	12	31	156	450	906	1287	1420	1204	1026	546	260	78	7376
	Sioux City	A	34.0	0	9	108	369	867	1240	1435	1198	989	483	214	39	6951
	Waterloo	A	32.6	12	19	138	428	909	1296	1460	1221	1023	531	229	54	7320
Kans	Concordia	A	40.4	0	0	57	276	705	1023	1163	935	781	372	149	18	5479
	Dodge City	A	42.5	0	0	33	251	666	939	1051	840	719	354	124	9	4986
	Goodland	A	37.8	0	6	81	381	810	1073	1166	955	884	507	236	42	6141
	Topeka	A	41.7	0	0	57	270	672	980	1122	893	722	330	124	12	5182
	Wichita	A	44.2	0	0	33	229	618	905	1023	804	645	270	87	6	4620
Ky	Covington	A	41.4	0	0	75	291	669	983	1035	893	756	390	149	24	5265
	Lexington	A	43.8	0	0	54	239	609	902	946	818	685	325	105	0	4683
	Louisville	A	44.0	0	0	54	248	609	890	930	818	682	315	105	9	4660
La	Alexandria	A	57.5	0	0	0	56	273	431	471	361	260	69	0	0	1921
	Baton Rouge	A	59.8	0	0	0	31	216	369	409	294	208	33	0	0	1560
	Lake Charles	A	60.5	0	0	0	19	210	341	381	274	195	39	0	0	1459
	New Orleans	A	61.0	0	0	0	19	192	322	363	258	192	39	0	0	1385
	New Orleans	C	61.8	0	0	0	12	165	291	344	241	177	24	0	0	1254
	Shreveport	A	56.2	0	0	0	47	297	477	552	426	304	81	0	0	2184
Me	Caribou	A	24.4	78	115	336	682	1044	1535	1690	1470	1308	858	468	183	9767
	Portland	A	33.0	12	53	195	508	807	1215	1339	1182	1042	675	372	111	7511
Md	Baltimore	A	43.7	0	0	48	264	585	905	936	820	679	327	90	0	4654
	Baltimore	C	46.2	0	0	27	189	486	806	859	762	629	288	65	0	4111
	Frederick	A	42.0	0	0	66	307	624	955	995	876	741	384	127	12	5087
Mass.	Boston	A	40.0	0	9	60	316	603	983	1088	972	846	513	208	36	5634
	Nantucket	A	40.2	12	22	93	332	573	896	992	941	896	621	384	129	5891
	Pittsfield	A	32.6	25	59	219	524	831	1231	1339	1196	1063	660	326	105	7578
	Worcester	A	34.7	6	34	147	450	774	1172	1271	1123	998	612	304	78	6969

Average Monthly and Yearly Degree Days for Cities in the United States and Canada (Base 65 F) (Continued)

State or Prov	Station		Avg Winter Temp[d]	July	Aug	Sept.	Oct	Nov	Dec.	Jan	Feb	Mar	Apr.	May	June	Yearly Total
	Memphis	C	51.6	0	0	12	102	396	648	710	568	434	129	16	0	3015
	Nashville	A	48.9	0	0	30	158	495	732	778	644	512	189	40	0	3578
	Oak Ridge	C	47.7	0	0	39	192	531	772	778	669	552	228	56	0	3817
Tex.	Abilene	A	53.9	0	0	0	99	366	586	642	470	347	114	0	0	2624
	Amarillo	A	47.0	0	0	18	205	570	797	877	664	546	252	56	0	3985
	Austin	A	59.1	0	0	0	31	225	388	468	325	223	51	0	0	1711
	Brownsville	A	67.7	0	0	0	0	66	149	205	106	74	0	0	0	600
	Corpus Christi	A	64.6	0	0	0	0	120	220	291	174	109	0	0	0	914
	Dallas	A	55.3	0	0	0	62	321	524	601	440	319	90	6	0	2363
	El Paso	A	52.9	0	0	0	84	414	648	685	445	319	105	0	0	2700
	Fort Worth	A	55.1	0	0	0	65	324	536	614	448	319	99	0	0	2405
	Galveston	A	62.2	0	0	0	6	147	276	360	263	189	33	0	0	1274
	Galveston	C	62.0	0	0	0	0	138	270	350	258	189	30	0	0	1235
	Houston	A	61.0	0	0	0	6	183	307	384	288	192	36	0	0	1396
	Houston	C	62.0	0	0	0	0	165	288	363	258	174	30	0	0	1278
	Laredo	A	66.0	0	0	0	0	105	217	267	134	74	0	0	0	797
	Lubbock	A	48.8	0	0	18	174	513	744	800	613	484	201	31	0	3578
	Midland	A	53.8	0	0	0	87	381	592	651	468	322	90	0	0	2591
	Port Arthur	A	60.5	0	0	0	22	207	329	384	274	192	39	0	0	1447
	San Angelo	A	56.0	0	0	0	68	318	536	567	412	288	66	0	0	2255
	San Antonio	A	60.1	0	0	0	31	204	363	428	286	195	39	0	0	1546
	Victoria	A	62.7	0	0	0	6	150	270	344	230	152	21	0	0	1173
	Waco	A	57.2	0	0	0	43	270	456	536	389	270	66	0	0	2030
	Wichita Falls	A	53.0	0	0	0	99	381	632	698	518	378	120	6	0	2832
Utah	Milford	A	36.5	0	0	99	443	867	1141	1252	988	822	519	279	87	6497
	Salt Lake City	A	38.4	0	0	81	419	849	1082	1172	910	763	459	233	84	6052
	Wendover	A	39.1	0	0	48	372	822	1091	1178	902	729	408	177	51	5778
Vt	Burlington	A	29.4	28	65	207	539	891	1349	1513	1333	1187	714	353	90	8269
Va	Cape Henry	C	50.0	0	0	0	112	360	645	694	633	536	246	53	0	3279
	Lynchburg	A	46.0	0	0	51	223	540	822	849	731	605	267	78	0	4166
	Norfolk	A	49.2	0	0	0	136	408	698	738	655	533	216	37	0	3421
	Richmond	A	47.3	0	0	36	214	495	784	815	703	546	219	53	0	3865
	Roanoke	A	46.1	0	0	51	229	549	825	834	722	614	261	65	0	4150
Wash	Olympia	A	44.2	68	71	198	422	636	753	834	675	645	450	307	177	5236
	Seattle-Tacoma	A	44.2	56	62	162	391	633	750	828	678	657	474	295	159	5145
	Seattle	C	46.9	50	47	129	329	543	657	738	599	577	396	242	117	4424
	Spokane	A	36.5	9	25	168	493	879	1082	1231	980	834	531	288	135	6655
	Walla Walla	C	43.8	0	0	87	310	681	843	986	745	589	342	177	45	4805
	Yakima	A	39.1	0	12	144	450	828	1039	1163	868	713	435	220	69	5941
W. Va.	Charleston	A	44.8	0	0	63	254	591	865	880	770	648	300	96	9	4476
	Elkins	A	40.1	9	25	135	400	729	992	1008	896	791	444	198	48	5675
	Huntington	A	45.0	0	0	63	257	585	856	880	764	636	294	99	12	4446
	Parkersburg	C	43.5	0	0	60	264	606	905	942	826	691	339	115	6	4754
Wisc	Green Bay	A	30.3	28	50	174	484	924	1333	1494	1313	1141	654	335	99	8029
	La Crosse	A	31.5	12	19	153	437	924	1339	1504	1277	1070	540	245	69	7589
	Madison	A	30.9	25	40	174	474	930	1330	1473	1274	1113	618	310	102	7863
	Milwaukee	A	32.6	43	47	174	471	876	1252	1376	1193	1054	642	372	135	7635
Wyo	Casper	A	33.4	6	16	192	524	942	1169	1290	1084	1020	657	381	129	7410
	Cheyenne	A	34.2	28	37	219	543	909	1085	1212	1042	1026	702	428	150	7381
	Lander	A	31.4	6	19	204	555	1020	1299	1417	1145	1017	654	381	153	7870
	Sheridan	A	32.5	25	31	219	539	948	1200	1355	1154	1051	642	366	150	7680
Alta	Banff	C	—	220	295	498	797	1185	1485	1624	1364	1237	855	589	402	10551
	Calgary	A	—	109	186	402	719	1110	1389	1575	1379	1268	798	477	291	9703
	Edmonton	A	—	74	180	411	738	1215	1603	1810	1520	1330	765	400	222	10268
	Lethbridge	A	—	56	112	318	611	1011	1277	1497	1291	1159	696	403	213	8644
B. C.	Kamloops	A	—	22	40	189	546	894	1138	1314	1057	818	462	217	102	6799
	Prince George*	A	—	236	251	444	747	1110	1420	1612	1319	1122	747	468	279	9755
	Prince Rupert	C	—	273	248	339	539	708	868	936	808	812	648	493	357	7029
	Vancouver*	A	—	81	87	219	456	657	787	862	723	676	501	310	156	5515
	Victoria*	A	—	136	140	225	462	663	775	840	718	691	504	341	204	5699
	Victoria	C	—	172	184	243	426	607	723	805	668	660	487	354	250	5579

Average Monthly and Yearly Degree Days for Cities in the United States and Canada (Base 65 F) (Concluded)

State or Prov.	Station		Avg Winter Temp[d]	July	Aug	Sept.	Oct	Nov.	Dec.	Jan	Feb.	Mar	Apr	May	June	Yearly Total
Man.	Brandon*	A	—	47	90	357	747	1290	1792	2034	1737	1476	837	431	198	11036
	Churchill	A	—	360	375	681	1082	1620	2248	2558	2277	2130	1569	1153	675	16728
	The Pas	C	—	59	127	429	831	1440	1981	2232	1853	1624	969	508	228	12281
	Winnipeg	A	—	38	71	322	683	1251	1757	2008	1719	1465	813	405	147	10679
N B	Fredericton*	A	—	78	68	234	592	915	1392	1541	1379	1172	753	406	141	8671
	Moncton	C	—	62	105	276	611	891	1342	1482	1336	1194	789	468	171	8727
	St John	C	—	109	102	246	527	807	1194	1370	1229	1097	756	490	249	8219
Nfld	Argentia	A	—	260	167	294	564	750	1001	1159	1085	1091	879	707	483	8440
	Corner Brook	C	—	102	133	324	642	873	1194	1358	1283	1212	885	639	333	8978
	Gander	A	—	121	152	330	670	909	1231	1370	1266	1243	939	657	366	9254
	Goose*	A	—	130	205	444	843	1227	1745	1947	1689	1494	1074	741	348	11887
	St John's*	A	—	186	180	342	651	831	1113	1262	1170	1187	927	710	432	8991
N W T	Aklavik	C	—	273	459	807	1414	2064	2530	2632	2336	2282	1674	1063	483	18017
	Fort Norman	C	—	164	341	666	1234	1959	2474	2592	2209	2058	1386	732	294	16109
	Resolution Island	C	—	843	831	900	1113	1311	1724	2021	1850	1817	1488	1181	942	16021
N. S	Halifax	C	—	58	51	180	457	710	1074	1213	1122	1030	742	487	237	7361
	Sydney	A	—	62	71	219	518	765	1113	1262	1206	1150	840	567	276	8049
	Yarmouth	A	—	102	115	225	471	696	1029	1156	1065	1004	726	493	258	7340
Ont	Cochrane	C	—	96	180	405	760	1233	1776	1978	1701	1528	963	570	222	11412
	Fort William	A	—	90	133	366	694	1140	1597	1792	1557	1380	876	543	237	10405
	Kapuskasing	C	—	74	171	405	756	1245	1807	2037	1735	1562	978	580	222	11572
	Kitchener	C	—	16	59	177	505	855	1234	1342	1226	1101	663	322	66	7566
	London	A	—	12	43	159	477	837	1206	1305	1198	1066	648	332	66	7349
	North Bay	C	—	37	90	267	608	990	1507	1680	1463	1277	780	400	120	9219
	Ottawa	C	—	25	81	222	567	936	1469	1624	1441	1231	708	341	90	8735
	Toronto	C	—	7	18	151	439	760	1111	1233	1119	1013	616	298	62	6827
P.E.I	Charlottetown	C	—	40	53	198	518	804	1215	1380	1274	1169	813	496	204	8164
	Summerside	C	—	47	84	216	546	840	1246	1438	1291	1206	841	518	216	8488
Que	Arvida	C	—	102	136	327	682	1074	1659	1879	1619	1407	891	521	231	10528
	Montreal*	A	—	9	43	165	521	882	1392	1566	1381	1175	684	316	69	8203
	Montreal	C	—	16	28	165	496	864	1355	1510	1328	1138	657	288	54	7899
	Quebec*	A	—	56	84	273	636	996	1516	1665	1477	1296	819	428	126	9372
	Quebec	C	—	40	68	243	592	972	1473	1612	1418	1228	780	400	111	8937
Sasks	Prince Albert	A	—	81	136	414	797	1368	1872	2108	1763	1559	867	446	219	11630
	Regina	A	—	78	93	360	741	1284	1711	1965	1687	1473	804	409	201	10806
	Saskatoon	C	—	56	87	372	750	1302	1758	2006	1689	1463	798	403	186	10870
Y T	Dawson	C	—	164	326	645	1197	1875	2415	2561	2150	1838	1068	570	258	15067
	Mayo Landing	C	—	208	366	648	1135	1794	2325	2427	1992	1665	1020	580	294	14454

*The data for these normals were from the full ten-year period 1951-1960, adjusted to the standard normal period 1931 1960

TABLES F & G

Radiation and Other Data for 80 Locations in the United States

($\bar{I}_H$ Monthly average daily total radiation on a horizontal surface, Btu/day-ft^2; $\bar{K}_t$=the fraction of the extra terrestrial radiation transmitted through the atmosphere, t_o=average daytime ambient temperature, °F)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ALASKA													
Annette Is.	$\bar{I}_H$	236.2	428.4	883.4	1357.2	1634.7	1638.7	1632.1	1269.4	962	454.6	220.3	152
Lat 55°02'N	$\bar{K}_t$	0.427	0.415	0.492	0.507	0.484	0.441	0.454	0.427	0.449	0.347	0.304	0.361
El. 110 ft.	t_o	35.8	37.5	39.7	44.4	51.0	56.2	58.6	59.8	54.8	48.2	41.9	37.4
Barrow	$\bar{I}_H$	13.3	143.2	713.3	1491.5	1883	2055.3	1602.2	953.5	428.4	152.4	22.9	-
Lat. 71°20'N	$\bar{K}_t$	-	0.776	0.773	0.726	0.553	0.533	0.448	0.377	0.315	0.35	-	-
El. 22 ft.	t_o	-13.2	-15.9	-12.7	2.1	20.5	35.4	41.6	40.0	31.7	18.6	2.6	-8.6
Bethel	$\bar{I}_H$	142.4	404.8	1052.4	1662.3	1711.8	1698.1	1401.8	938.7	755	430.6	164.9	83
Lat.60°47'N	$\bar{K}_t$	0.536	0.557	0.704	0.675	0.519	0.458	0.398	0.336	0.406	0.432	0.399	0.459
El. 125 ft.	t_o	9.2	11.6	14.2	29.4	42.7	55.5	56.9	54.8	47.4	33.7	19.0	9.4
Fairbanks	$\bar{I}_H$	66	283.4	860.5	1481.2	1806.2	1970.8	1702.9	1247.6	699.6	323.6	104.1	20.3
Lat.64°49'N	$\bar{K}_t$	0.639	0.556	0.674	0.647	0.546	0.529	0.485	0.463	0.419	0.416	0.47	0.458
El. 436 ft.	t_o	-7.0	0.3	13.0	32.2	50.5	62.4	63.8	58.3	47.1	29.6	5.5	-6.6
Matanuska	$\bar{I}_H$	119.2	345	-	1327.6	1628.4	1727.6	1526.9	1169	737.3	373.8	142.8	56.4
Lat.61°30'N	$\bar{K}_t$	0.513	0.503	-	0.545	0.494	0.466	0.434	0.419	0.401	0.390	0.372	0.36
El. 180 ft.	t_o	13.9	21.0	27.4	38.6	50.3	57.6	60.1	58.1	50.2	37.7	22.9	13.9
ALBERTA													
Edmonton	$\bar{I}_H$	331.7	652.4	1165.3	1541.7	1900.4	1914.4	1964.9	1528	1113.3	704.4	413.6	245
Lat.53°35'N	$\bar{K}_t$	0.529	0.585	0.624	0.564	0.558	0.514	0.549	0.506	0.506	0.504	0.510	0.492
El. 2219 ft.	t_o	10.4	14	26.3	42.9	55.4	61.3	66.6	63.2	54.2	44.1	26.7	14.0
ARKANSAS													
Little Rock	$\bar{I}_H$	704.4	974.2	1335.8	1669.4	1960.1	2091.5	2081.2	1938.7	1640.6	1282.6	913.6	701.1
Lat.34°44'N	$\bar{K}_t$	0.424	0.458	0.496	0.513	0.545	0.559	0.566	0.574	0.561	0.552	0.484	0.463
El. 265 ft.	t_o	44.6	48.5	56.0	65.8	73.1	70.7	85.1	84.6	78.3	67.9	54.7	46.7
ARIZONA													
Phoenix	$\bar{I}_H$	1126.6	1514.7	1967.1	2388.2	2709.6	2781.5	2450.5	2299.6	2131.3	1688.9	1290	1040.9
Lat.33°26'N	$\bar{K}_t$	0.65	0.691	0.716	0.728	0.753	0.745	0.667	0.677	.722	0.708	0.657	0.652
El. 1112 ft.	t_o	54.2	58.8	64.7	72.2	80.8	89.2	94.6	92.5	87.4	75.8	63.6	56.7
Tucson	$\bar{I}_H$	1171.9	1453.8	-	2434.7	-	2601.4	2292.2	2179.7	2122.5	1640.9	1322.1	1132.1
Lat. 32°07'N	$\bar{K}_t$	0.648	0.646	-	0.738	-	0.698	0.625	0.640	0.710	0.672	0.650	0.679
El. 2556 ft.	t_o	53.7	57.3	62.3	69.7	78.0	87.0	90.1	87.4	84.0	73.9	62.5	56.1
CALIFORNIA													
Davis	$\bar{I}_H$	599.2	945	1504	1959	2368.6	2619.2	2565.6	2287.8	1856.8	1239.5	795.6	550.5
Lat. 38°33'N	$\bar{K}_t$	0.416	0.490	0.591	0.617	0.662	0.697	0.697	0.687	0.664	0.598	0.477	0.421
El. 51 ft.	t_o	47.6	52.1	56.8	63.1	69.6	75.7	81	79.4	76.7	67.8	57	48.7
Fresno	$\bar{I}_H$	712.9	1116.6	1652.8	2049.4	2409.2	2641.7	2512.2	2300.7	1897.8	1415.5	906.6	616.6
Lat. 36°46'N	$\bar{K}_t$	0.462	0.551	0.632	0 638	0.672	0.703	0.682	0.686	0.665	0.635	0.512	0.44
El. 331 ft.	t_o	47.3	53.9	59.1	65.6	73.5	80.7	87.5	84.9	78.6	68.7	57.3	48.9
Inyokern	$\bar{I}_H$	1148.7	1554.2	2136.9	2594.8	2925.4	3108.8	2908.8	2759.4	2409.2	1819.2	3170.1	1094.4
Lat. 35° 39'N	$\bar{K}_t$	0.716	0.745	0.803	0.8	0.815	0.830	0.790	0.820	0.834	0.795	0.743	0.742
El. 2440 ft.	t_o	47.3	53.9	59.1	65.6	73 5	80.7	87.5	84.9	78.6	68.7	57.3	48.9
Los Angeles, (WBO)	$\bar{I}_H$	911.8	1223.6	1640.9	1866.8	2061.2	2259	2428.4	2198.9	1891.5	1362.3	1053.1	877.8
Lat.34°03'N	$\bar{K}_t$	0.538	0.568	0.602	0.571	0.573	0.605	0.66	0.648	0.643	0.578	0.548	0.566
El. 99 ft.	t_o	57.9	59.2	61.8	64.3	67.6	70.7	75.8	76.1	74.2	69.6	65.4	60.2
Los Angeles, (WBAS)	$\bar{I}_H$	930.6	1284.1	1729.5	1948	2196.7	2272.3	2413.6	2155.3	1898.1	1372.7	1082.3	901.1
Lat. 33°56'N	$\bar{K}_t$	0.547	0.596	0.635	0.595	0.610	0.608	0.657	0.635	0.641	0.574	0.551	0.566
El. 99 ft.	t_o	56.2	56.9	59.2	61.4	64.2	66.7	69.6	70.2	69.1	66.1	62.6	58.7
Riverside	$\bar{I}_H$	999.6	1335	1750.5	1943.2	2282.3	2492.6	2443.5	2263.8	1955.3	1509.6	1169	979.7
Lat. 33°57'N	$\bar{K}_t$	0.589	0.617	0.643	0.594	0.635	0.667	0.665	0.668	0.665	0.639	0.606	0.626
El. 1020 ft.	t_o	55.3	57.0	60.6	65.0	69.4	74.0	81.0	81.0	78.5	71.0	63.1	57.2
Santa Maria	$\bar{I}_H$	983.8	1296.3	1805.9	2067.9	2375.6	2599.6	2540.6	2293.3	1965.7	1566.4	1169	943.9
Lat. 34°54'N	$\bar{K}_t$	0.595	0.613	0.671	0.636	0.661	0.695	0.690	0.678	0.674	0.676	0.624	0.627
El. 238 ft.	t_o	54.1	55.3	57.6	59.5	61.2	63.5	65.3	65.7	65.9	64.1	60.8	56.1
COLORADO													
Grand Junction	$\bar{I}_H$	848	1210.7	1622.9	2002.2	2300.3	2645.4	2517.7	2157.2	1957.5	1394.8	969.7	793.4
Lat. 39°07'N	$\bar{K}_t$	0.597	0.633	0.643	0.632	0.643	0.704	0.690	0.65	0.705	0.654	0.59	0.621
El. 4849 ft.	t_o	26.9	35.0	44.6	55.8	66.3	75.7	82.5	79.6	71.4	58.3	42.0	31.4
Grand Lake	$\bar{I}_H$	735	1135.4	1579.3	1876.7	1974.9	2369.7	2103.3	1708.5	1715.8	1212.2	775.6	660.5
Lat. 40°15'N	$\bar{K}_t$	0.541	0.615	0.637	0.597	0.553	0.63	0.572	0.516	0.626	0.583	0.494	0.542
El. 8389 ft.	t_o	18.5	23.1	28.5	39.1	48.7	56.6	62.8	61.5	55.5	45.2	30.3	22.6

From: Applications of Solar Energy for Heating and Cooling of Buildings, ASHRAE

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
DISTRICT OF COLUMBIA													
Washington (WBCO)........	$\bar{I}_H$	632.4	901.5	1255	1600.4	1846.8	2080.8	1929.9	1712.2	1446.1	1083.4	763.5	594.1
Lat. 38°51'N............	$\bar{K}_t$	0.445	0.470	0.496	0.504	0.516	0.553	0.524	0.516	0.520	0.506	0.464	0.460
El. 64 ft...............	t_o	38.4	39.6	48.1	57.5	67.7	76.2	79.9	77.9	72.2	60.9	50.2	40.2
FLORIDA													
Apalachicola............	$\bar{I}_H$	1107	1378.2	1654 2	2040.9	2268.6	2195.9	1978.6	1912.9	1703.3	1544.6	1243.2	982.3
Lat. 29°45'N............	$\bar{K}_t$	0.577	0.584	0.576	0 612	0.630	0.594	0.542	0.558	0.559	0.608	0.574	0.543
El. 35 ft...............	t_o	57.3	59.0	62.9	69.5	76.4	81.8	83.1	83.1	80.6	73.2	63.7	58.55
Gainesville.............	$\bar{I}_H$	1036.9	1324.7	1635	1956.4	1934.7	1960.9	1895 6	1873.8	1615.1	1312.2	1169.7	919.5
Lat. 29°39'N............	$\bar{K}_t$	0.535	0.56	0.568	0.587	0.538	0.531	0.519	0.547	0.529	0.515	0.537	0.508
El. 165 ft..............	t_o	62.1	63.1	67.5	72.8	79.4	83.4	83.8	84.1	82	75.7	67.2	62.4
Miami...................	$\bar{I}_H$	1292.2	1554.6	1828.8	2020.6	2068.6	1991.5	1992.6	1890.8	1646.8	1436.5	1321	1183.4
Lat. 25°47'N............	$\bar{K}_t$	0.604	0.616	0.612	0.600	0.578	0.545	0.552	0.549	0.525	0.534	0.559	0.588
El. 9 ft................	t_o	71.6	72.0	73.8	77.0	79.9	82.9	84.1	84.5	83.3	80.2	75.6	72.6
Tampa...................	$\bar{I}_H$	1223.6	1461.2	1771.9	2016.2	2228	2146.5	1991:9	1845.4	1687.8	1493.3	1328.4	1119.5
Lat. 27°55'N............	$\bar{K}_t$	0.605	0.600	0.606	0.602	0.620	0.583	0 548	0.537	0.546	0.572	0.590	0.589
El. 11 ft...............	t_o	64.2	65.7	68.8	74.3	79.4	83.0	84.0	84.4	82.9	77.2	69.6	65.5
GEORGIA													
Atlanta.................	$\bar{I}_H$	848	1080.1	1426.9	1807	2618.1	2002.6	2002.9	1898.1	1519.2	1290.8	997.8	751.[illegible]
Lat. 33°39'N............	$\bar{K}_t$	0.493	0.496	0.522	0 551	0.561	0 564	0.545	0.559	0.515	0.543	0 510	0.474
El. 976 ft..............	t_o	47.2	49.6	55.9	65.0	73.2	80.9	82.4	81.6	77.4	66.5	54.8	47.7
Griffin.................	$\bar{I}_H$	889.6	1135 8	1450.9	1923 6	2163 1	2176	2064.9	1961.2	1605.9	1352.4	1073.8	781.5
Lat. 33°15'N............	$\bar{K}_t$	0.513	0.517	0.528	0.586	0.601	0.583	0.562	0.578	0.543	0.565	0.545	0.487
El. 980 ft..............	t_o	48.9	51.0	59.1	66.7	74.6	81.2	83.0	82.2	78.4	68	57.3	49.4
IDAHO													
Boise...................	$\bar{I}_H$	518.8	884.9	1280.4	1814.4	2189.3	2376.7	2500.3	2149.4	1717.7	1128.4	678.6	456.8
Lat. 43°34'N............	$\bar{K}_t$	0.446	0.533	0.548	0.594	0.619	0.631	0.684	0.660	0.656	0.588	0.494	0.442
El. 2844 ft.............	t_o	29.5	36 5	45 0	53 5	62.1	69.3	79.6	77.2	66.7	56.3	42.3	33.1
ILLINOIS													
Lemont..................	$\bar{I}_H$	(590)	879	1255.7	1481.5	1866	2041 7	1990.8	1836.9	1469.4	1015.5	(639)	(531)
Lat. 41°40'N............	$\bar{K}_t$	(0.464)	0.496	0.520	0.477	0 525	0 542	0.542	0.559	0.547	0.506	(0.433)	(0.467)
El 595 ft...............	t_o	28.9	30.3	39.5	49.7	59.2	70 8	75.6	74.3	67.2	57.6	43.0	30 6
INDIANA													
Indianapolis............	$\bar{I}_H$	526.2	797.4	1184 1	1481.2	1828	2042	2039.5	1832.1	1513 3	1094 4	662.4	491.1
Lat. 39°44'N............	$\bar{K}_t$	0 380	0.424	0 472	0.47	0.511	0.543	0.554	0 552	0.549	0.520	0.413	0.391
El. 793 ft..............	t_o	31 3	33 9	43.0	54.1	64.9	74.8	79.6	77.4	70.6	59.3	44.2	33.4
KANSAS													
Dodge City..............	$\bar{I}_H$	953.1	1186.3	1565.7	1975.6	2126.5	2459.8	2400.7	2210 7	1841 7	1421	1065.3	873.8
Lat. 37°46'N............	$\bar{K}_t$	0.639	0.598	0.606	0.618	0.594	0 655	0.652	0.663	0 654	0.650	0.625	0.652
El. 2592 ft.............	t_o	33.8	38 7	46 5	57.7	66.7	77.2	83 8	82 4	73 7	61.7	46.5	36.8
KENTUCKY													
Lexington...............	$\bar{I}_H$	-	-	-	1834.7	2171.2	-	2246.5	2064.9	1775.6	1315.8	-	681.5
Lat. 38°02'N............	$\bar{K}_t$	-	-	-	0.575	0.606	-	0.610	0.619	0 631	0.604	-	0.513
El. 979 ft..............	t_o	36.5	38.8	47.4	57.8	67.5	76.2	79.8	78.2	72.8	61.2	47.6	38.5
LOUISIANA													
Lake Charles............	$\bar{I}_H$	899.2	1145.7	1487.4	1801.8	2080.4	2213 3	1968.6	1910.3	1678.2	1505.5	1122.1	875.6
Lat. 30°13'N............	$\bar{K}_t$	0.473	0.492	0.521	0.542	0.578	0.597	0.538	0.558	0.553	0.597	0.524	0.494
El. 12 ft...............	t_o	55.3	58.7	63.5	70.9	77.4	83 4	84.8	85.0	81 5	73.8	62.6	56.9
MAINE													
Caribou.................	$\bar{I}_H$	497	861.6	1360.1	1495.9	1779.7	1779.7	1898.1	1675.6	1254 6	793	415.5	398 9
Lat. 46°52'N............	$\bar{K}_t$	0 504	0 579	0.619	0.507	0.509	0.473	0.522	0.527	0.506	0.455	0.352	0.470
El. 628 ft..............	t_o	11.5	12.8	24.4	37.3	51.8	61 6	67.2	65.0	56 2	44.7	31.3	16.8
Portland................	$\bar{I}_H$	565.7	874.5	1329.5	1528.4	1923.2	2017.3	2095.6	1799.2	1428.8	1035	591.5	507.7
Lat. 43°39'N............	$\bar{K}_t$	0.482	0.524	0 569	0.500	0.544	0 536	0.572	0.554	0.546	0.539	0.431	0.491
El. 63 ft...............	t_o	23.7	24 5	34.4	44.8	55.4	65.1	71.1	69.7	61.9	51 8	40.3	28.0
MANITOBA													
Winnipeg................	$\bar{I}_H$	488.2	835.4	1354.2	1641.3	1904.4	1962	2123.6	1761.2	1190.4	767.5	444.6	345
Lat. 49°54'N............	$\bar{K}_t$	0.601	0.636	0.661	0.574	0.550	0.524	0.587	0.567	0 504	0.482	0.436	0.503
El. 786 ft..............	t_o	3.2	7.1	21.3	40.9	55.9	65.3	71.9	69.4	58 6	45.6	25.2	10.1
MASSACHUSETTS													
Blue Hill...............	$\bar{I}_H$	555.3	797	1143.9	1438	1776.4	1943.9	1881.5	1622.1	1314	941	592.2	482.3
Lat. 42°13'N............	$\bar{K}_t$	0.445	0 458	0.477	0.464	0.501	0.516	0.513	0.495	0.492	0.472	0.406	0.436
El. 629 ft..............	t_o	28.3	28 3	36.9	46 9	58.5	67.2	72.3	70.6	64.2	54.1	43.3	31.5
Boston..................	$\bar{I}_H$	505.5	738	1067 1	1355	1769	1864	1860.5	1570.1	1267 5	896.7	535.8	442.8
Lat. 42°22'N............	$\bar{K}_t$	0.410	0.426	0.445	0.438	0.499	0.495	0.507	0.480	0.477	0 453	0 372	0.400
El. 29 ft...............	t_o	31.4	31.4	39.9	49.5	60.4	69.8	74.5	73.8	66 8	57.4	46.6	34.9

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		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MASSACHUSETTS (Contd.)													
East Wareham............	$\bar{I}_H$	504.4	762.4	1132.1	1392.6	1704.8	1958.3	1873.8	1607.4	1363.8	996.7	636.2	521
Lat. 41°46'N............	$\bar{K}_t$	0.398	0.431	0.469	0.449	0.480	0.520	0.511	0.489	0.508	0.496	0.431	0.461
El. 18 ft...............	t_o	32.2	31.6	39.0	48.3	58.9	67.5	74.1	72.8	65.9	56	46	34.8
MICHIGAN													
East Lansing............	$\bar{I}_H$	425.8	739.1	1086	1249.8	1732.8	1914	1884.5	1627.7	1303.3	891.5	473.1	379.7
Lat. 42°44'N............	$\bar{K}_t$	0.35	0.431	0.456	0.406	0.489	0.508	0.514	0.498	0.493	0.456	0.333	0.349
El. 856 ft..............	t_o	26.0	26.4	35.7	48.4	59.8	70.3	74.5	72.4	65.0	53.5	40.0	29.0
Sault Ste. Marie........	$\bar{I}_H$	488.6	843.9	1336.5	1559.4	1962.3	2064.2	2149.4	1767.9	1207	809.2	392.2	359.8
Lat. 46°28'N............	$\bar{K}_t$	0.490	0.560	0.606	0.526	0.560	0.549	0.590	0.554	0.481	0.457	0.323	0.408
El. 724 ft..............	t_o	16.3	16.2	25.6	39.5	52.1	61.6	67.3	66.0	57.9	46.8	33.4	21.9
MINNESOTA													
St. Cloud...............	$\bar{I}_H$	632.8	976.7	1383	1598.1	1859.4	2003.3	2087.8	1828.4	1369.4	890.4	565.4	463.1
Lat. 45°35'N............	$\bar{K}_t$	0.595	0.629	0.614	0.534	0.530	0.533	0.573	0.570	0.539	0.490	0.435	0.504
El. 1034 ft.............	t_o	13.6	16.9	29.8	46.2	58.8	68.5	74.4	71.9	62.5	50.2	32.1	18.3
MISSOURI													
Columbia................	$\bar{I}_H$	651.3	941.3	1315.8	1631.3	1999.6	2129.1	2148.7	1953.1	1689.6	1202.6	839.5	590.4
Lat. 38°58'N............	$\bar{K}_t$	0.458	0.492	0.520	0.514	0.559	0.566	0.585	0.588	0.606	0.562	0.510	0.457
El. 785 ft..............	t_o	32.5	36.5	45.9	57.7	66.7	75.9	81.1	79.4	71.9	61.4	46.1	35.8
MONTANA													
Glasgow.................	$\bar{I}_H$	572.7	965.7	1437.6	1741.3	2127.3	2261.6	2414.7	1984.5	1531	997	574.9	428.4
Lat. 48°13'N............	$\bar{K}_t$	0.621	0.678	0.672	0.597	0.611	0.602	0.666	0.630	0.629	0.593	0.516	0.548
El. 2277 ft.............	t_o	13.3	17.3	31.1	47.8	59.3	67.3	76	73.2	61.2	49.2	31.0	18.6
Great Falls.............	$\bar{I}_H$	524	869.4	1369.7	1621.4	1970.8	2179.3	2383	1986.3	1536.5	984.9	575.3	420.7
Lat. 47°29'N............	$\bar{K}_t$	0.552	0.596	0.631	0.551	0.565	0.580	0.656	0.627	0.626	0.574	0.503	0.518
El. 3664 ft.............	t_o	25.4	27.6	35.6	47.7	57.5	64.3	73.8	71.3	60.6	51.4	38.0	29.1
NEBRASKA													
Lincoln.................	$\bar{I}_H$	712.5	955.7	1299.6	1587.8	1856.1	2040.6	2011.4	1902.6	1543.5	1215.8	773.4	643.2
Lat. 40°51'N............	$\bar{K}_t$	0.542	0.528	0.532	0.507	0.522	0.542	0.547	0.577	0.568	0.596	0.508	0.545
El. 1189 ft.............	t_o	27.8	32.1	42.4	55.8	65.8	76.0	82.6	80.2	71.5	59.9	43.2	31.8
NEVADA													
Ely.....................	$\bar{I}_H$	871.6	1255	1749.8	2103.3	2322.1	2649	2417	2307.7	1935	1473	1078.6	814.8
Lat. 39°17'N............	$\bar{K}_t$	0.618	0.660	0.692	0.664	0.649	0.704	0.656	0.695	0.696	0.691	0.658	0.64
El. 6262 ft.............	t_o	27.3	32.1	39.5	48.3	57.0	65.4	74.5	72.3	63.7	52.1	39.9	31.1
Las Vegas...............	$\bar{I}_H$	1035.8	1438	1926.5	2322.8	2629.5	2799.2	2524	2342	2062	1602.6	1190	964.2
Lat. 36°05'N............	$\bar{K}_t$	0.654	0.697	0.728	0.719	0.732	0.746	0.685	0.697	0.716	0.704	0.657	0.668
El. 2162 ft.............	t_o	47.5	53.9	60.3	69.5	78.3	88.2	95.0	92.9	85.4	71.7	57.8	50.2
NEW JERSEY													
Seabrook................	$\bar{I}_H$	591.9	854.2	1195.6	1518.8	1800.7	1964.6	1949.8	1715	1445.7	1071.9	721.8	522.5
Lat. 39°30'N............	$\bar{K}_t$	0.426	0.453	0.476	0.481	0.504	0.522	0.530	0.517	0.524	0.508	0.449	0.416
El. 100 ft..............	t_o	39.5	37.6	43.9	54.7	64.9	74.1	79.8	77.7	69.7	61.2	48.5	39.3
NEW MEXICO													
Albuquerque.............	$\bar{I}_H$	1150.9	1453.9	1925.4	2343.5	2560.9	2757.5	2561.2	2387.8	2120.3	1639.8	1274.2	1051.6
Lat. 35°03'N............	$\bar{K}_t$	0.704	0.691	0.719	0.722	0.713	0.737	0.695	0.708	0.728	0.711	0.684	0.704
El. 5314 ft.............	t_o	37.3	43.3	50.1	59.6	69.4	79.1	82.8	80.6	73.6	62.1	47.8	39.4
NEW YORK													
Ithaca..................	$\bar{I}_H$	434.3	755	1074.9	1322.9	1779.3	2025.8	2031.3	1736.9	1320.3	918.4	466.4	370.8
Lat. 42°27'N............	$\bar{K}_t$	0.351	0.435	0.45	0.428	0.502	0.538	0.554	0.530	0.497	0.465	0.324	0.337
El. 950 ft..............	t_o	27.2	26.5	36	48.4	59.6	68.9	73.9	71.9	64.2	53.6	41.5	29.6
New York................	$\bar{I}_H$	539.5	790.8	1180.4	1426.2	1738.4	1994.1	1938.7	1605.9	1349.4	977.8	598.1	476
Lat. 40°46'N............	$\bar{K}_t$	0.406	0.435	0.480	0.455	0.488	0.53	0.528	0.486	0.500	0.475	0.397	0.403
El. 52 ft...............	t_o	35.0	34.9	43.1	52.3	63.3	72.2	76.9	75.3	69.5	59.3	48.3	37.7
Sayville................	$\bar{I}_H$	602.9	936.2	1259.4	1560.5	1057.2	2123.2	2040.9	1734.7	1446.8	1087.4	697.8	533.9
Lat. 40°30'N............	$\bar{K}_t$	0.453	0.511	0.510	0.498	0.522	0.564	0.555	0.525	0.530	0.527	0.450	0.447
El. 20 ft...............	t_o	35	34.9	43.1	52.3	63.3	72.2	76.9	75.3	69.5	59.3	48.3	37.7
Schenectady.............	$\bar{I}_H$	488.2	753.5	1026.6	1272.3	1553.1	1687.8	1662.3	1494.8	1124.7	820.6	436.2	356.8
Lat. 42°50'N............	$\bar{K}_t$	0.406	0.441	0.433	0.413	0.438	0.448	0.454	0.458	0.426	0.420	0.309	0.331
El. 217 ft..............	t_o	24.7	24.6	34.9	48.3	61.7	70.8	76.9	73.7	64.6	53.1	40.1	28.0
Upton...................	$\bar{I}_H$	581	872.7	1280.4	1609.9	1891.5	2159	2044.6	1789.6	1472.7	1102.6	686.7	551.3
Lat. 40°52'N............	$\bar{K}_t$	0.444	0.483	0.522	0.514	0.532	0.574	0.557	0.542	0.542	0.538	0.448	0.467
El. 75 ft...............	t_o	35.0	34.9	43.1	52.3	63.3	72.2	76.9	75.3	69.5	59.3	48.3	37.7
NORTH CAROLINA													
Greensboro..............	$\bar{I}_H$	743.9	1031.7	1323.2	1755.3	1988.5	2111.4	2033.9	1810.3	1517.3	1202.6	908.1	690.8
Lat. 36°05'N............	$\bar{K}_t$	0.469	0.499	0.499	0.543	0.554	0.563	0.552	0.538	0.527	0.531	0.501	0.479
El. 891 ft..............	t_o	42.0	44.2	51.7	60.8	69.9	78.0	80.2	78.9	73.9	62.7	51.5	43.2

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
NORTH CAROLINA (Contd.)													
Hatteras................	$\bar{I}_H$	891.9	1184.1	1590.4	2128	2376.4	2438	2334.3	2085.6	1758.3	1337.6	1053.5	798.1
Lat. 35°13'N...........	$\bar{K}_t$	0.546	0.563	0.593	0.655	0.661	0.652	0.634	0.619	0.605	0.58	0.566	0.535
El. 7 ft...............	t_o	49.9	49.5	54.7	61.5	69.9	77.2	80.0	79.8	76.7	67.9	59.1	51.3
NORTH DAKOTA													
Bismarck................	$\bar{I}_H$	587.4	934.3	1328.4	1668.2	2056.1	2173.8	2305.5	1929.1	1441.3	1018.1	600.4	464.2
Lat. 46°47'N...........	$\bar{K}_t$	0.594	0.628	0.605	0.565	0.588	0.579	0.634	0.606	0.581	0.584	0.510	0.547
El. 1660 ft............	t_o	12.4	15.9	29.7	46.6	58.6	67.9	76.1	73.5	61.6	49.6	31.4	18.4
OHIO													
Cleveland...............	$\bar{I}_H$	466.8	681.9	1207	1443.9	1928.4	2102.6	2094.4	1840.6	1410.3	997	526.6	427.3
Lat. 41°24'N...........	$\bar{K}_t$	0.361	0.383	0.497	0.464	0.543	0.559	0.571	0.559	0.524	0.491	0.351	0.371
El.805 ft..............	t_o	30.8	30.9	39.4	50.2	62.4	72.7	77.0	75.1	68.5	57.4	44.0	32.8
Columbus................	$\bar{I}_H$	486.3	746.5	1112.5	1480.8	1839.1	(2111)	2041.3	1572.7	1189.3	919.5	479	430.2
Lat. 40°00'N...........	$\bar{K}_t$	0.356	0.401	0.447	0.470	0.515	(0.561)	0.555	0.475	0.433	0.441	0.302	0.351
El. 833 ft.............	t_o	32.1	33.7	42.7	53.5	64.4	74.2	78	75.9	70.1	58	44.5	34.0
OKLAHOMA													
Oklahoma City...........	$\bar{I}_H$	938	1192.6	1534.3	1849.4	2005.1	2355	2273.8	2211	1819.2	1409.6	1085.6	897.4
Lat. 35°24'N...........	$\bar{K}_t$	0.580	0.571	0.576	0.570	0.558	0.629	0.618	0.565	0.628	0.614	0.588	0.608
El. 1304 ft............	t_o	40.1	45.0	53.2	63.6	71.2	80.6	85.5	85.4	77.4	66.5	52.2	43.1
Stillwater..............	$\bar{I}_H$	763.8	1081.5	1463.8	1702.6	1879.3	2235.8	2224.3	2039.1	1724.3	1314	991.5	783
Lat. 36°09'N...........	$\bar{K}_t$	0.484	0.527	0.555	0.528	0.523	0.596	0.604	0.607	0.599	0.581	0.548	0.544
El. 910 ft.............	t_o	41.2	45.6	53.8	64.2	71.6	81.1	85.9	85.9	77.5	67.6	52.6	43.9
ONTARIO													
Ottawa..................	$\bar{I}_H$	539.1	852.4	1250.5	1506.6	1857.2	2084.5	2045.4	1752.4	1326.6	826.9	458.7	408.5
Lat. 45°20'N...........	$\bar{K}_t$	0.499	0.540	0.554	0.502	0.529	0.554	0.560	0.546	0.521	0.450	0.359	0.436
El. 339 ft.............	t_o	14.6	15.6	27.7	43.3	57.5	67.5	71.9	69.8	61.5	48.9	35	19.6
Toronto.................	$\bar{I}_H$	451.3	674.5	1088.9	1388.2	1785.2	1941.7	1968.6	1622.5	1284.1	835	458.3	352.8
Lat. 43°41'N...........	$\bar{K}_t$	0.388	0.406	0.467	0.455	0.506	0.516	0.539	0.500	0.493	0.438	0.336	0.346
El. 379 ft.............	t_o	26.5	26.0	34.2	46.3	58	68.4	73.8	71.8	64.3	52.6	40.9	30.2
OREGON													
Astoria.................	$\bar{I}_H$	338.4	607	1008.5	1401.5	1838.7	1753.5	2007.7	1721	1322.5	780.4	413.6	295.2
Lat. 46°12'N...........	$\bar{K}_t$	0.330	0.397	0.454	0.471	0.524	0.466	0.551	0.538	0.526	0.435	0.336	0.332
El. 8 ft...............	t_o	41.3	44.7	46.9	51.3	55.0	59.3	62.6	63.6	62.2	55.7	48.5	43.9
Medford.................	$\bar{I}_H$	435.4	804.4	1259.8	1807.4	2216.2	2440.5	2607.4	2261.6	1672.3	1043.5	558.7	346.5
Lat. 42°23'N...........	$\bar{K}_t$	0.353	0.464	0.527	0.584	0.625	0.648	0.710	0.689	0.628	0.526	0.384	0.313
El. 1329 ft............	t_o	39.4	45.4	50.8	56.3	63.1	69.4	76.9	76.4	69.6	58.7	47.1	40.5
PENNSYLVANIA													
State College...........	$\bar{I}_H$	501.8	749.1	1106.6	1399.2	1754.6	2027.6	1968.2	1690	1336 1	1017	580.1	4443.9
Lat. 40°48'N...........	$\bar{K}_t$	0.381	0.413	0.451	0.448	0.493	0.539	0.536	0.512	0.492	0.496	0.379	0.376
El. 1175 ft............	t_o	31.3	31.4	39.8	51.3	63.4	71.8	75.8	73.4	66.1	55.6	43.2	32.6
RHODE ISLAND													
New Port................	$\bar{I}_H$	565.7	856.4	1231.7	1484.8	1849	2019.2	1942.8	1687.1	1411.4	1035.4	656.1	527.7
Lat. 41°29'N...........	$\bar{K}_t$	0.438	0.482	0.507	0.477	0.520	0.536	0.529	0.513	0.524	0.512	0.44	0.460
El. 60 ft..............	t_o	29.5	32.0	39.6	48.2	58.6	67.0	73.2	72.3	66.7	56.2	46.5	34.4
SOUTH CAROLINA													
Charleston..............	$\bar{I}_H$	946.1	1152.8	1352.4	1918.8	2063.4	2113.3	1649.4	1933.6	1557.2	1332.1	1073.8	952
Lat. 32°54'N...........	$\bar{K}_t$	0.541	0.521	0.491	0.584	0.574	0.567	0.454	0.569	0.525	0.554	0.539	0.586
El. 46 ft..............	t_o	53.6	55.2	60.6	67.8	74.8	80.9	82.9	82.3	79.1	69.8	59.8	54.0
SOUTH DAKOTA													
Rapid City..............	$\bar{I}_H$	687.8	1032.5	1503.7	1807	2028	2193.7	2235.8	2019.9	1628	1179.3	763.1	590.4
Lat. 44°09'N...........	$\bar{K}_t$	0.601	0.627	0.649	0.594	0.574	0.583	0.612	0.622	0.628	0.624	0.566	0.588
El. 3218 ft............	t_o	24.7	27.4	34.7	48.2	58.3	67.3	76.3	75.0	64.7	52.9	38.7	29.2
TEXAS													
Brownsville.............	$\bar{I}_H$	1105.9	1262.7	1505.9	1714	2092.2	2288.5	2345	2124	1774.9	1536.5	1104.8	982.3
Lat. 25°55'N...........	$\bar{K}_t$	0.517	0.500	0.505	0.509	0.584	0.627	0.650	0.617	0.566	0.570	0.468	0.488
El. 20 ft..............	t_o	63.3	66.7	70.7	76.2	81.4	85.1	86.5	86.9	84.1	78.9	70.7	65.2
El Paso.................	$\bar{I}_H$	1247.6	1612.9	2048.7	2447.2	2673	2731	2391.1	2350.5	2077.5	1704.8	1324.7	1051.6
Lat. 31°48'N...........	$\bar{K}_t$	0.686	0.714	0.730	0.741	0.743	0.733	0.652	0.669	0.693	0.695	0.647	0.626
El. 3916 ft............	t_o	47.1	53.1	58.7	67.3	75.7	84 2	84.9	83.4	78.5	69.0	56.0	48 5
Fort Worth..............	$\bar{I}_H$	936.2	1198.5	1597.8	1829.1	2105.1	2437.6	2293.3	2216.6	1880.8	1476	1147.6	913.6
Lat. 32°50'N...........	$\bar{K}_t$	0.530	0.541	0.577	0.556	0.585	0.654	0 624	0.653	0.634	0.612	0.576	0.563
El. 544 ft.............	t_o	48.1	52.3	59.8	68.8	75.9	84.0	87.7	88.6	81.3	71.5	58.8	50.8

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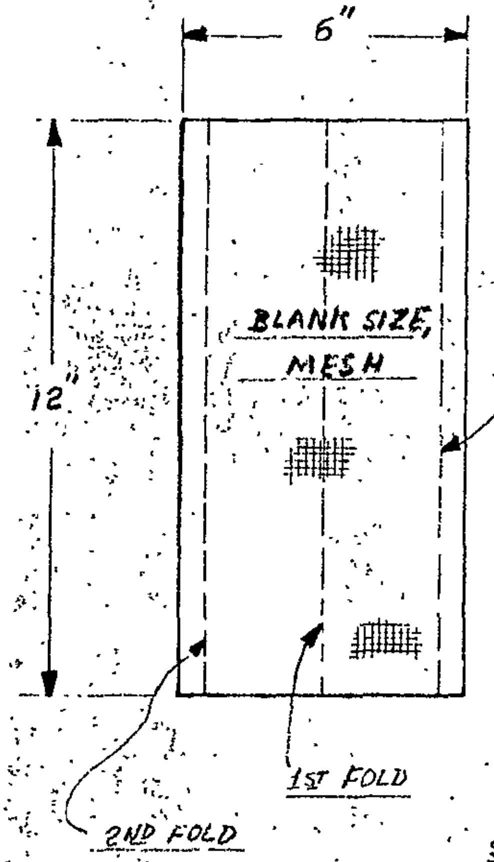
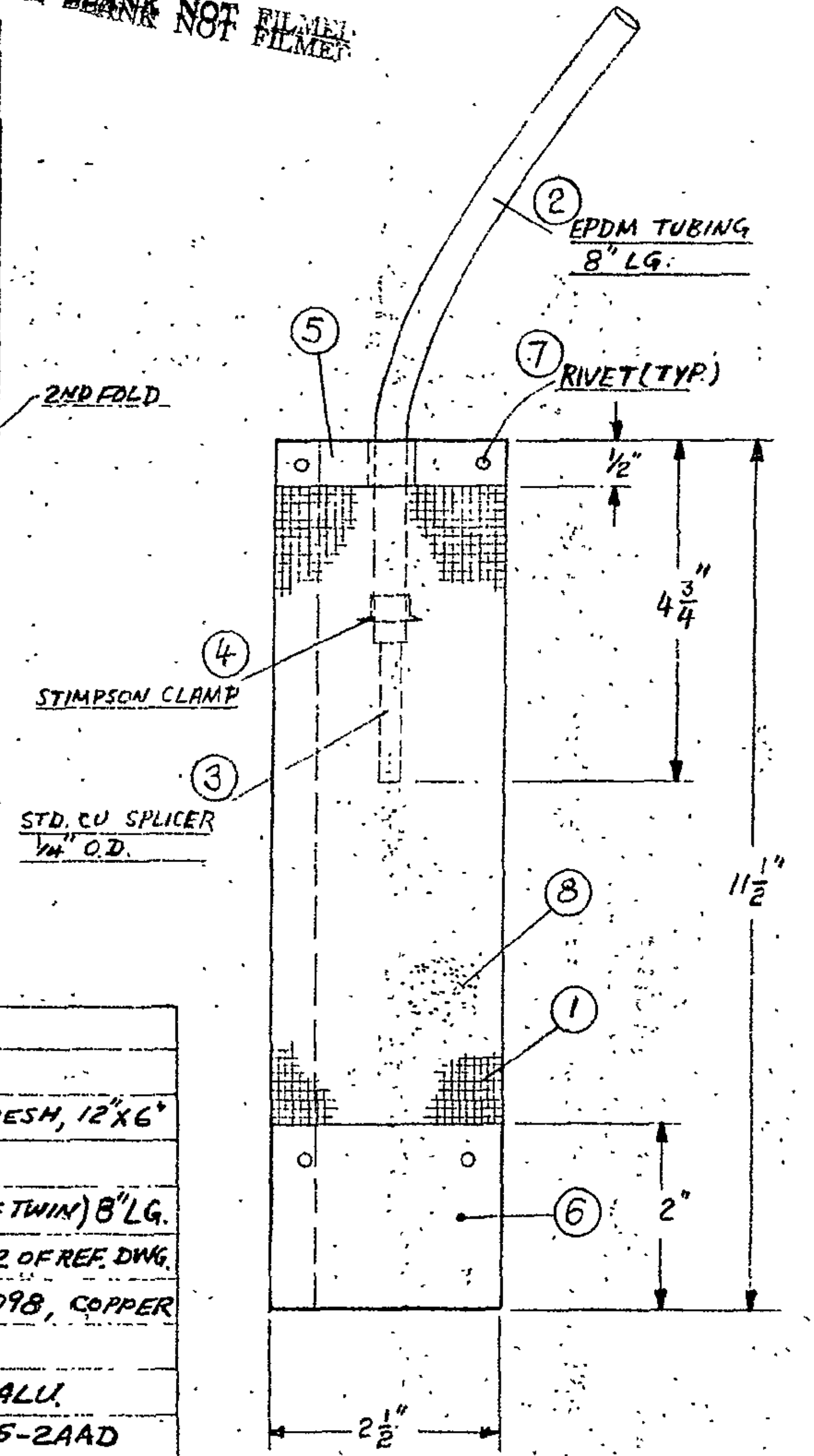
TEXAS (Contd.)													
Midland................	$\bar{I}_H$	1066.4	1345.7	1784.8	2036.1	2301.1	2317.7	2301.8	2193	1921.8	1470.8	1244.3	1023.2
Lat. 31°56'N..........	K_t	0.587	0.596	0.638	0.617	0.639	0.622	0.628	0.643	0.642	0.600	0.609	0.611
El. 2854 ft...........	t_o	47.9	52.8	60.0	68.8	77.2	83.9	85.7	85.0	78.9	70.3	56.6	49.1
San Antonio...........	$\bar{I}_H$	1045	1299.2	1560.1	1664.6	2024.7	2250*	2364.2	2185.2	1844.6	1487.4	1104.4	954.6
Lat. 29°32'N..........	K_t	0.541	0.550	0.542	0.500	0.563	0.62	0.647	0.637	0.603	0.584	0.507	0.528
El. 794 ft............	t_o	53.7	58.4	65.0	72.2	79.2	85.0	87.4	87.8	82.6	74.7	63.3	56.5
TENNESSEE													
Nashville.............	$\bar{I}_H$	589.7	907	1246.8	1662.3	1997	2149.4	2079.7	1862.7	1600.7	1223.6	823.2	614.4
Lat. 36°07'N..........	K_t	0.373	0.440	0.472	0.514	0.556	0.573	0.565	0.554	0.556	0.540	0.454	0.426
El. 605 ft............	t_o	42.6	45.1	52.9	63.0	71.4	80.1	83.2	81.9	76.6	65.4	52.3	44.3
Oak Ridge.............	$\bar{I}_H$	604	895.9	1241.7	1689.6	1942.8	2066.4	1972.3	1795.6	1559.8	1194.8	796.3	610
Lat. 36°01'N..........	K_t	0.382	0.435	0.471	0.524	0.541	0.551	0.536	0.534	0.542	0.527	0.438	0.422
El. 905 ft............	t_o	41.9	44.2	51.7	61.4	69.8	77.8	80.2	78.8	74.5	62.7	50.4	42.5
UTAH													
Salt Lake City........	$\bar{I}_H$	622.1	986	1301.1	1813.3	-	-	-	-	1689.3	1250.2	-	552.8
Lat. 40°46'N..........	K_t	0.468	0.909	0.529	0.579	-	-	-	-	0.621	0.610	-	0.467
El. 4227 ft...........	t_o	29.4	36.2	44.4	53.9	63.1	71.7	81.3	79.0	68.7	57.0	42.5	34.0
WASHINGTON													
Seattle...............	$\bar{I}_H$	282.6	520.6	992.2	1507	1881.5	1909.9	2110.7	1688.5	1211.8	702.2	306.3	239.5
Lat. 47°27'N..........	K_t	0.296	0.355	0.456	0.510	0.538	0.508	0.581	0.533	0.492	0.407	0.336	0.292
El. 386 ft............	t_o	42.1	45.0	48.9	54.1	59.8	64.4	68.4	67.9	63.3	56.3	48.4	44.4
Seattle...............	$\bar{I}_H$	252	471.6	917.3	1375.6	1664.9	1724	1805.1	1617	1129.1	638	325.5	218.1
Lat. 47°36'N..........	K_t	0.266	0.324	0.423	0.468	0.477	0.459	0.498	0.511	0.459	0.372	0.284	0.269
El. 14 ft.............	t_o	38.9	42.9	46.9	51.9	58.1	62.8	67.2	66.7	61.6	54.0	45.7	41.5
Spokane...............	$\bar{I}_H$	446.1	837.6	1200	1864.6	2104.4	2226.5	2479.7	2076	1511	844.6	486.3	279
Lat. 47°40'N..........	K_t	0.478	0.579	0.556	0.602	0.603	0.593	0.684	0.656	0.616	0.494	0.428	0.345
El.1968 ft............	t_o	26.5	31.7	40.5	49.2	57.9	64.6	73.4	71.7	62.7	51.5	37.4	30.5
WISCONSIN													
Madison...............	$\bar{I}_H$	564.6	812.2	1232.1	1455.3	1745.4	2031.7	2046.5	1740.2	1443.9	993	555.7	495.9
Lat. 43°08'N..........	K_t	0.40	0.478	0.522	0.474	0.493	0.540	0.559	0.534	0.549	0.510	0.396	0.467
El. 866 ft............	t_o	21.8	24.6	35.3	49.0	61.0	70.9	76.8	74.4	65.6	53.7	37.8	25.4
WYOMING													
Lander................	$\bar{I}_H$	786.3	1146.1	1638	1988.5	2114	2492.2	2438.4	2120.6	1712.9	1301.8	837.3	694.8
Lat. 42°48'N..........	K_t	0.65	0.672	0.691	0.647	0.597	0.662	0.665	0.649	0.647	0.666	0.589	0.643
El. 5370 ft...........	t_o	20.2	26.3	34.7	45.5	56.0	65.4	74.6	72.5	61.4	48.3	33.4	23.8

*Original values incorrect. Values estimated from insolation maps.



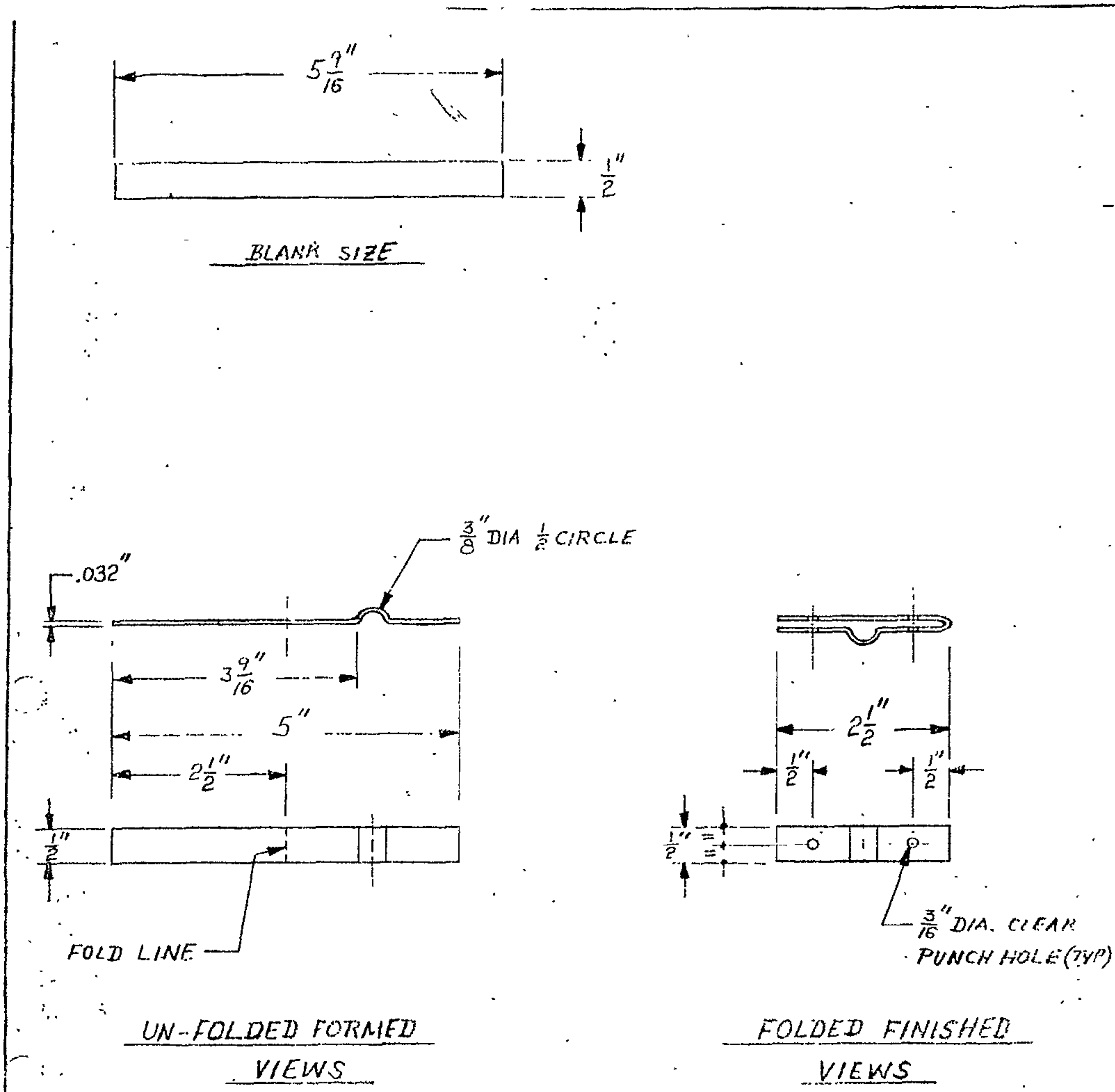


REF. DWG.	BILL OF MTRL.		
	ITEM	QTY	MATERIAL
A-S113	1	1	ALUMINUM SCREEN, 20 MESH, 12"X6"
A-130P	2	1	EPDM TUB., SINGLE (½ OF TWIN) 8" LG.
A-6438	3	1	SPLICER, COPPER, ITEM 2 OF REF. DWG.
STIMPSON CATALOG.	4	1	STIMPSON CLAMP # 2098, COPPER
A-S114	5	1	RETAINER, TOP, ALU.
A-S115	6	1	RETAINER, BOTTOM, ALU.
STAR CAT.	7	4	BLIND RIVET, STAR # 6-2AAD
			RIVET DIA. 3/16", GRIP RANGE .020"-.125"
	8	5 OZS.	BLUE, INDICATING SILICA GEL, 6-16 MESH

Rev	By	Date	Revisions
A	Ɦ	7/28/77	MODIFIED

TOLERANCES: FRACTIONAL, ± 1/64 ; DECIMALS, ± .005 ; ANGLES, ± 1/2°

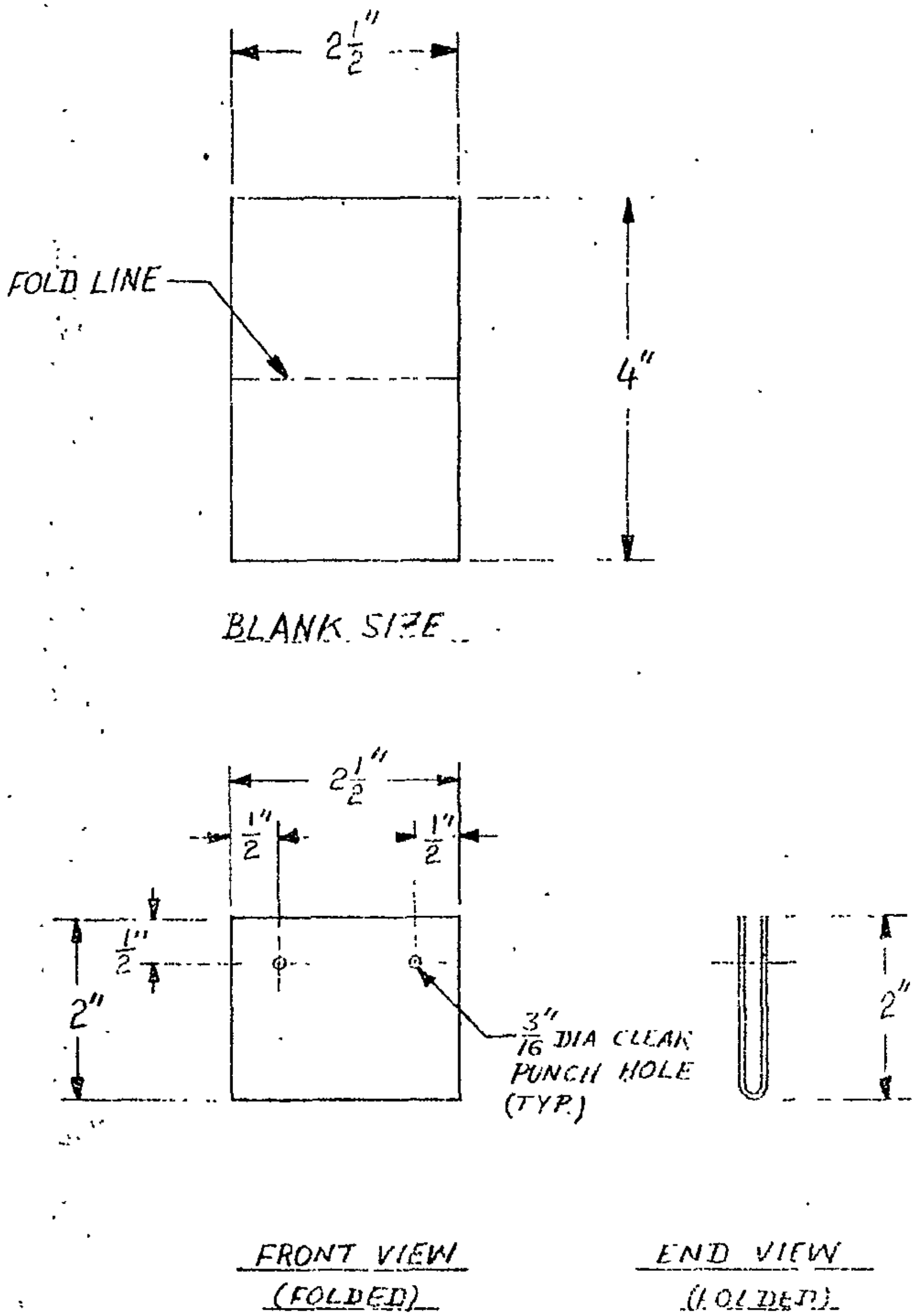
TITLE CONDENSATION DRIER	Tool No.	DRN. 5-20-77	CALMAC MFG. CORP. Englewood, N.J.
		CHK. Ɦ	
MATERIAL —	Blank Size	PROJ. SOL. EN'GY	A- S108-A
		SCALE —	



Rev	By	Date	Revisions

TOLERANCES: FRACTIONAL, ± 1/64 ; DECIMALS, ± .005 ; ANGLES, ± 1/2°

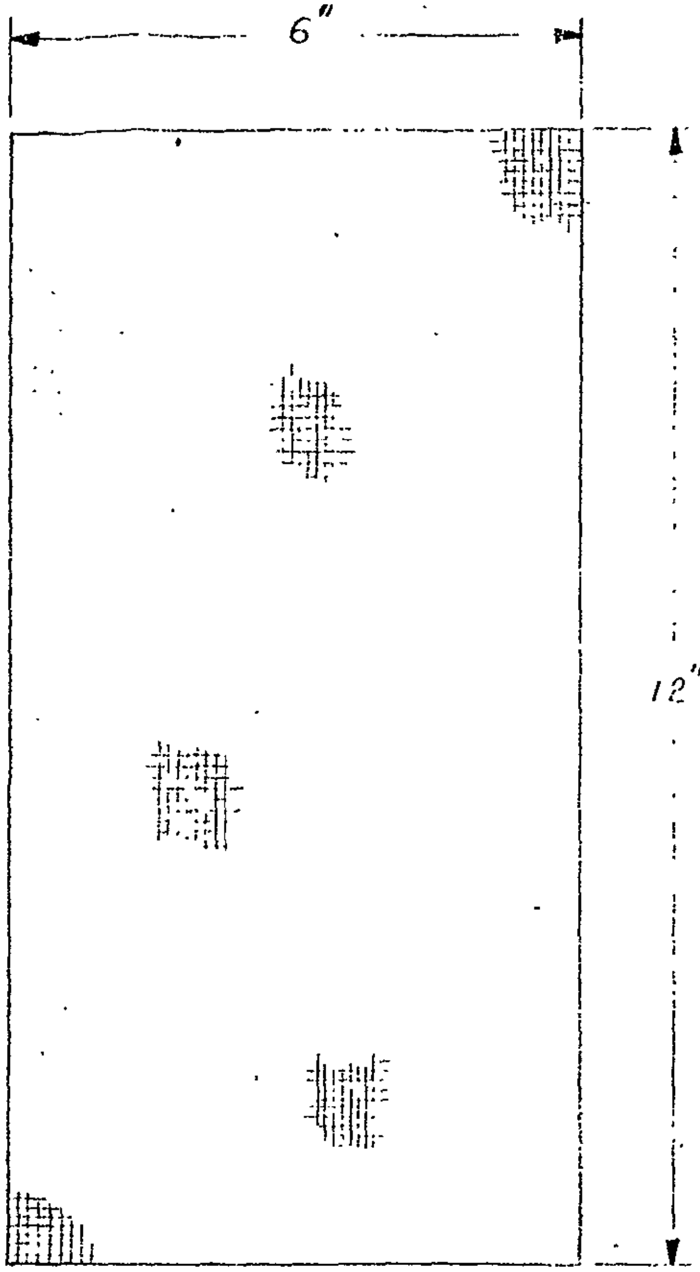
TITLE TOP RETAINER, DRIER	Tool No.	DRN. 7-12-77	CALMAC MFG. CORP. Englewood, N.J.
		CHK. C.F.T	
MATERIAL AL., TYPE 1100-H14, .032" THK	Blank Size	PROJ. SOL. ENGY	A-S114
		SCALE HALF	



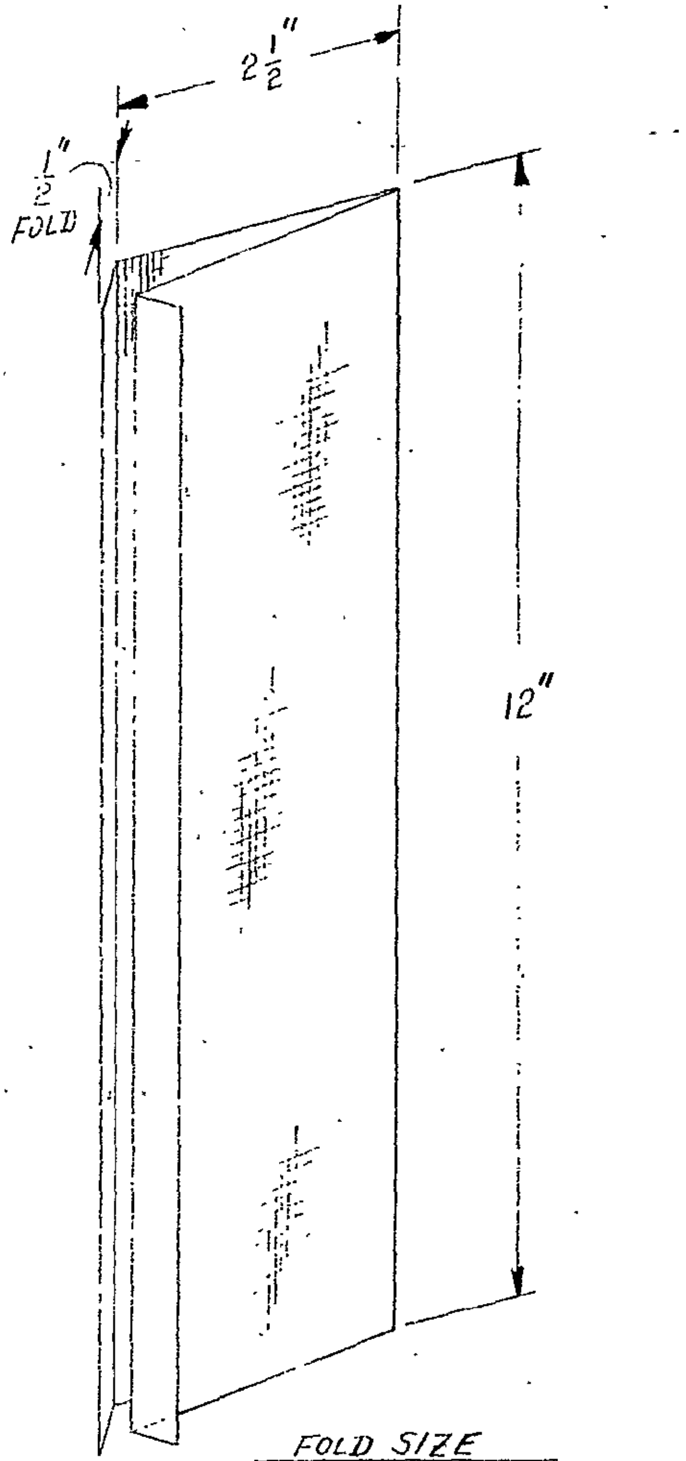
Rev	By	Date	Revisions

TOLERANCES: FRACTIONAL, ± 1/64 ; DECIMALS, ± .005 ; ANGLES, ± 1/2°

TITLE BOTTOM RETAINER, COND DRIER	Tool No.	DRN. 7-13-77	CALMAC MFG. CORP. Englewood, N.J.
		CHK.	
MATERIAL AL, TYPE 1100-H14, .032" THK.	Blank Size.	PROJ. SOL. ENGY	A-S115
		SCALE HALF	



BLANK SIZE



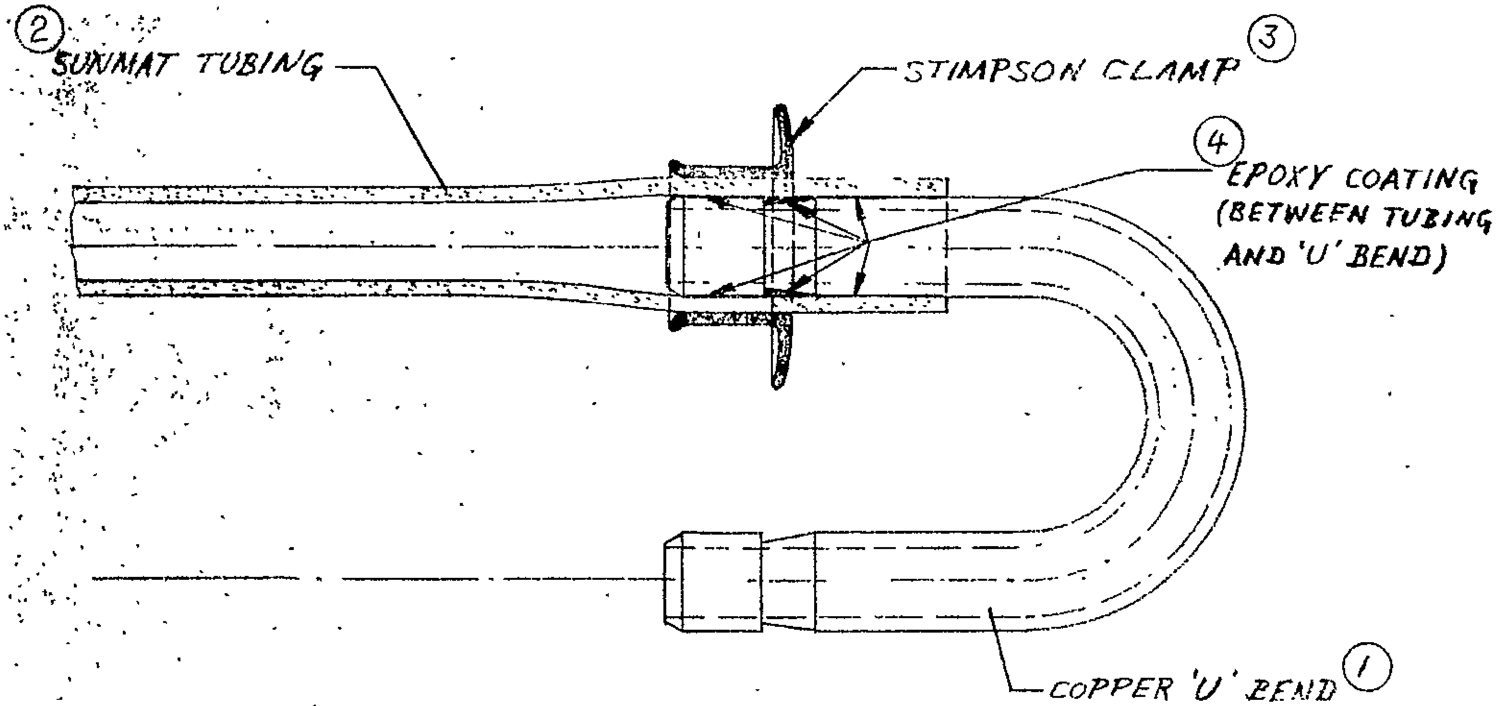
FOLD SIZE

MATERIAL: ALUMINUM SCREEN, 18X16 MESH .011 DIA. WIRE; MADE OF ALUMINUM ALLOY # 5056 OR EQUV. ALU. PAINT COATED.

Rev	By	Date	Revisions

TOLERANCES: FRACTIONAL, ± 1/64 ; DECIMALS, ± .005 ; ANGLES, ± 1/2°

TITLE: ALUMINUM SCREEN, COND. DRIER	Tool No.	DRN. 7-11-77	CALMAC MFG. CORP. Englewood, N.J.
		CHK.	
MATERIAL AS GIVEN ABOVE	Blank Size	PROJ. SOL. EN'GY	A- S113
		SCALE —	

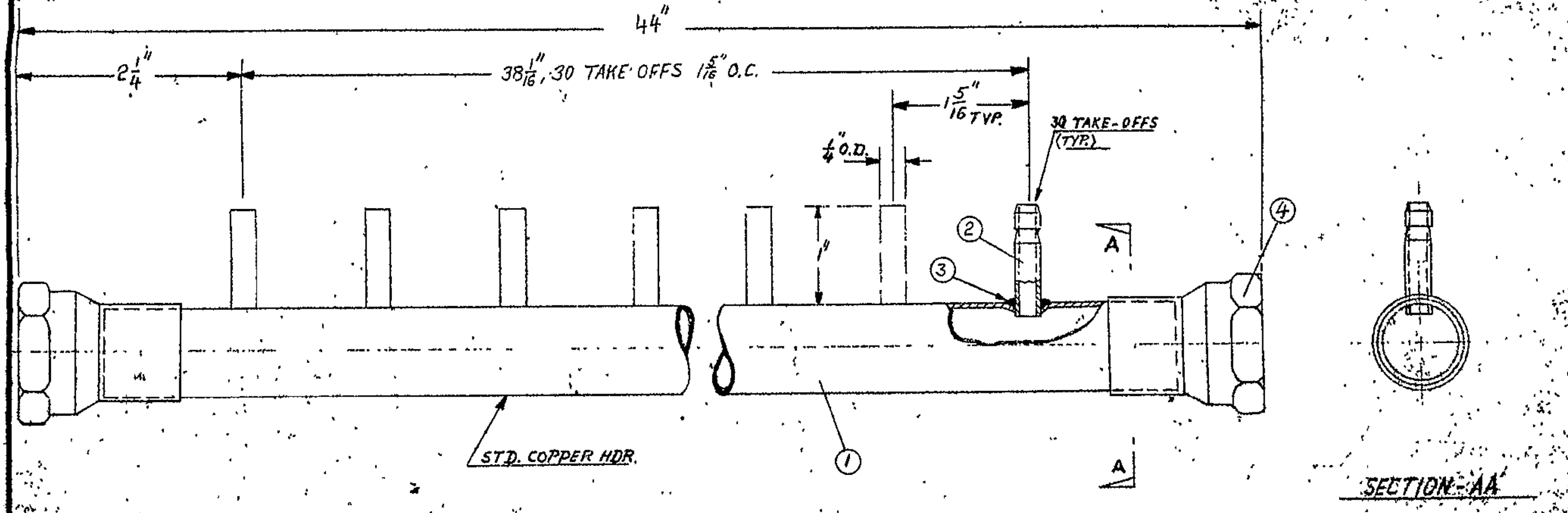


K&K CHEMICALS' DATA SH'TS.	4	AS REQ.	K&K CHEMICALS' ADHESIVE #305-1 MIXED WITH HARDNER # 305-2
STIMPSON CAT. DWG. #AS119	3	2	STIMPSON CLAMP # A2098 COPPER
A-130P	2	1	SUNMAT TWIN TUBING
A-S118	1	1	COPPER 'U' BEND
REF. DWG.	ITEM	QTY	MATERIAL
	BILL OF MATERIAL		

Rev	By	Date	Revisions
A	hz	7/28/77	'U' BEND GROVE DESIGN CHANGE EPOXY ADDED

TOLERANCES: FRACTIONAL, ± 1/64 ; DECIMALS, ± .005 ; ANGLES, ± 1/2°

TITLE 'U'-BEND END ASS'LY, SUNMAT	Tool No.	DRN. 5-25-77	CALMAC MFG. CORP. Englewood, N.J.
		CHK. hz	
MATERIAL AS SPEC.	Blank Size	PROJ. SOL. EN'GY	A-S109 A
		SCALE 1" = 1/2"	



REF. DWG.	ITEM	QTY	MATERIAL	
CAT.	4	2	3/4" ADAPTER FPTXC	COPPER
A-S111	3	30	SOLDER RING	
A-S117	2	30	1/4 O.D. COPPER TUBE NIPPLE, 1 5/8" LG.	
CAT.	1	1	3/4" COPPER PIPE TYPE 'L'	

BILL OF MATERIAL

REV.	BY	DATE	Revisions
D		10/5/77	MODIFIED
C		9/7/77	MODIFIED TO 30 TAKEOFFS
B		7/27/77	TAKE OFF DESIGN CHANGED
A		5/20/77	BILL OF MTRL. ADDED
A		5/20/77	MODIFIED FOR 31 TAKEOFFS

DO NOT SCALE THIS DRAWING.

TOLERANCES UNLESS OTHERWISE NOTED
FRACTIONAL ± 1/64 DECIMAL ± .005 ANGULAR ± 1/2

NAME: HEADER, SUNMAT

MATERIAL:

DRN 2-18-77

CHK.

APP.

PROJ. SOL. EN'GY.

SCALE FULL

CALMAC MFG. CORP.
Englewood, N.J.

B-ST 277-D

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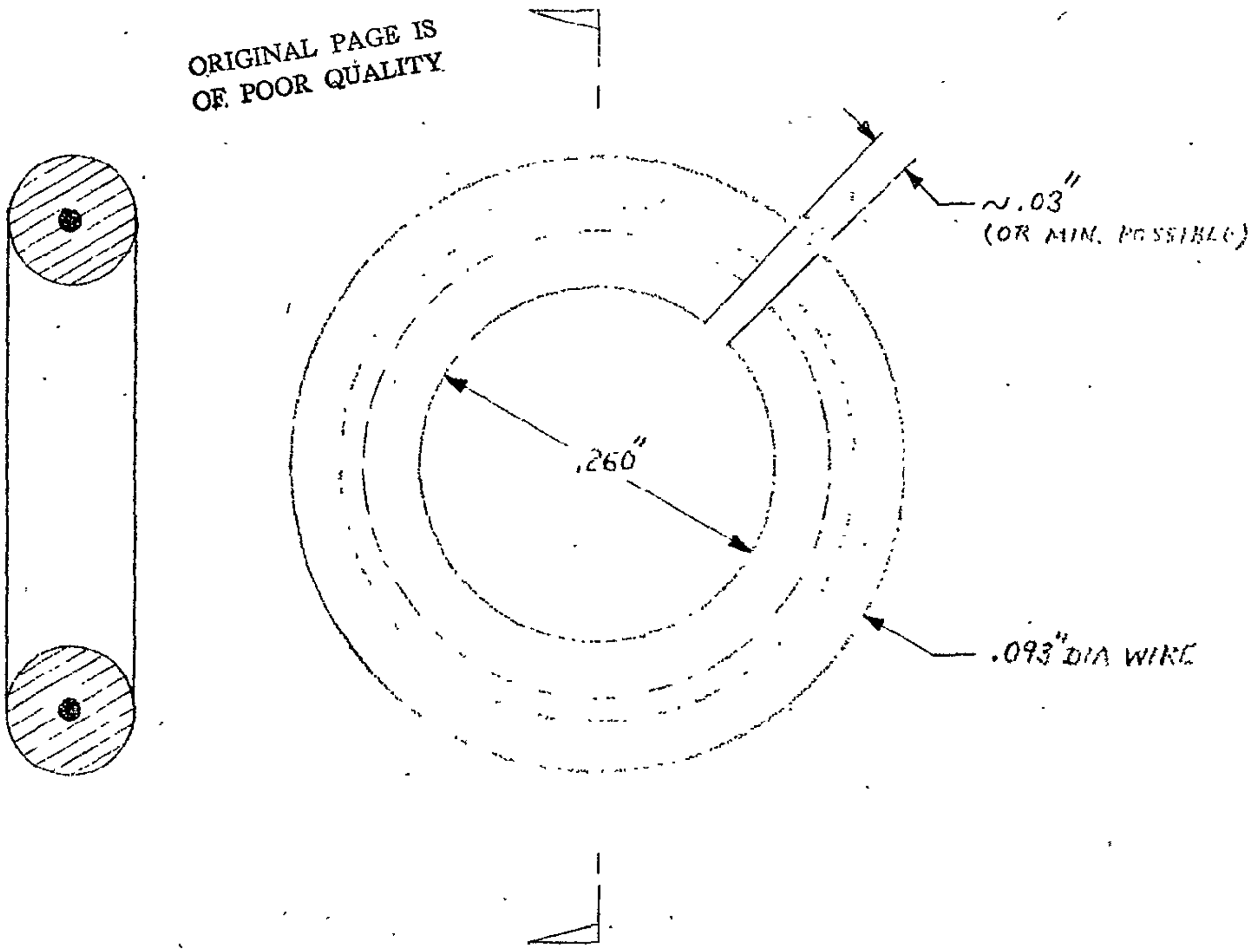
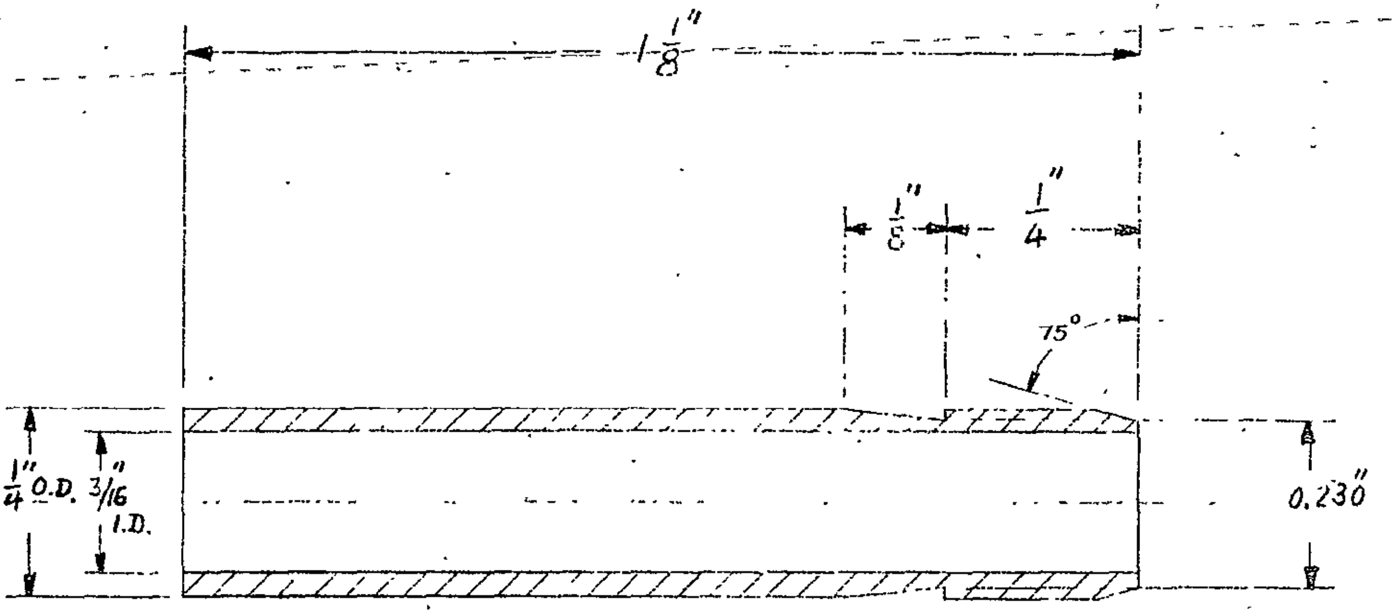


MATERIAL: 40% TIN, 60% LEAD
WITH 2.5% (MEDIUM) ROSIN CORE FLUX

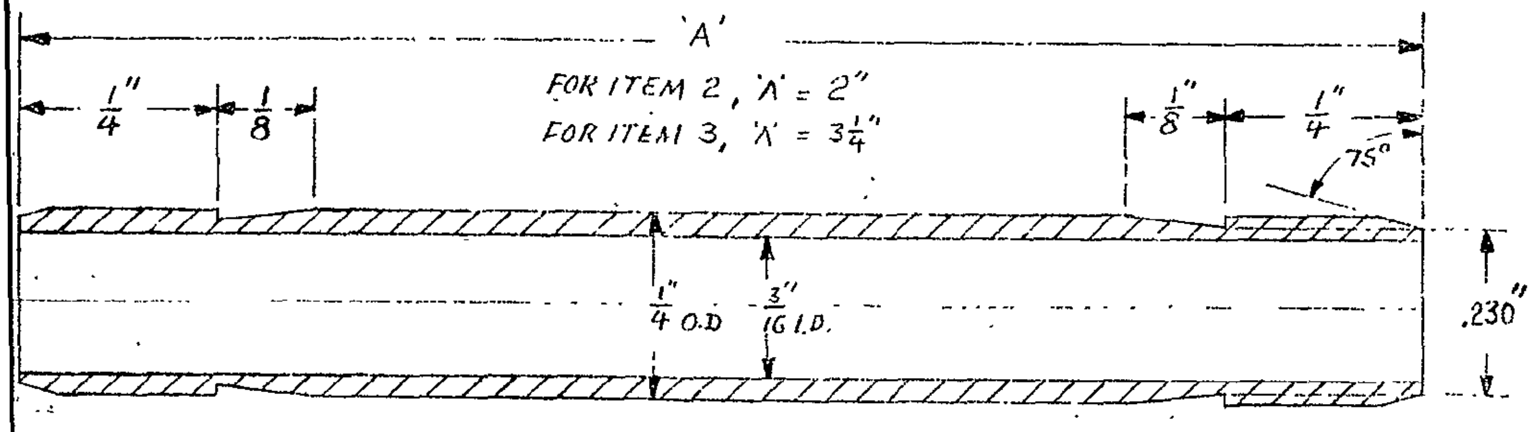
Rev	By	Date	Revisions

TOLERANCES: FRACTIONAL, ± 1/64 ; DECIMALS, ±.005 ; ANGLES, ± 1/2°

TITLE SOLDER RING, SUNMAT	Tool No.	DRN. 7-8-77	CALMAC MFG. CORP. Englewood, N.J.
		CHK	
MATERIAL GIVEN ABOVE	Blank Size	PROJ. SOL EN'GY	A-S111
		SCALE 8:1	



ITEM 1

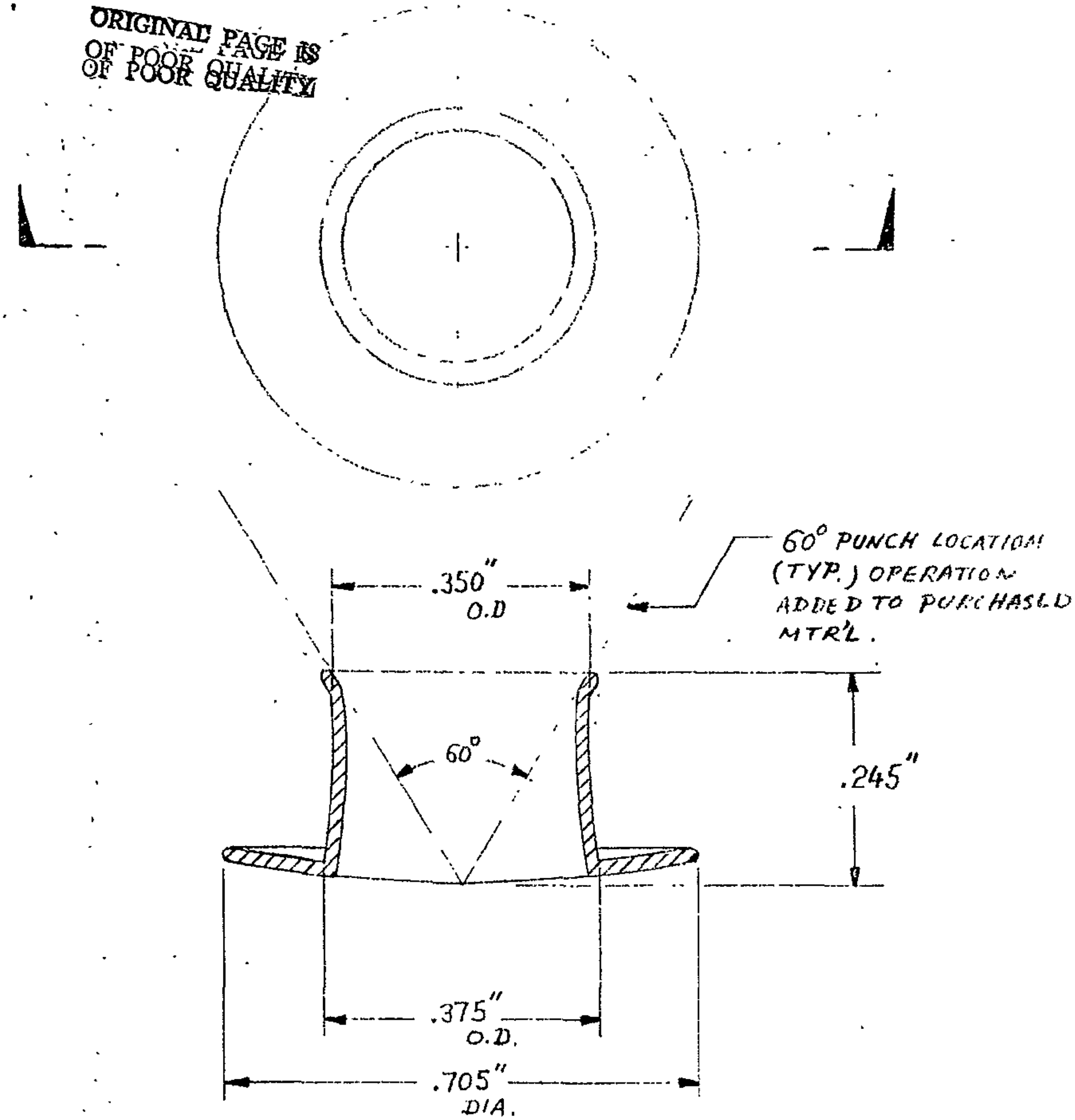


ITEMS 2 & 3

Rev	By	Date	Revisions

TOLERANCES: FRACTIONAL, ± 1/64 ; DECIMALS, ±.005 ; ANGLES, ± 1/2°

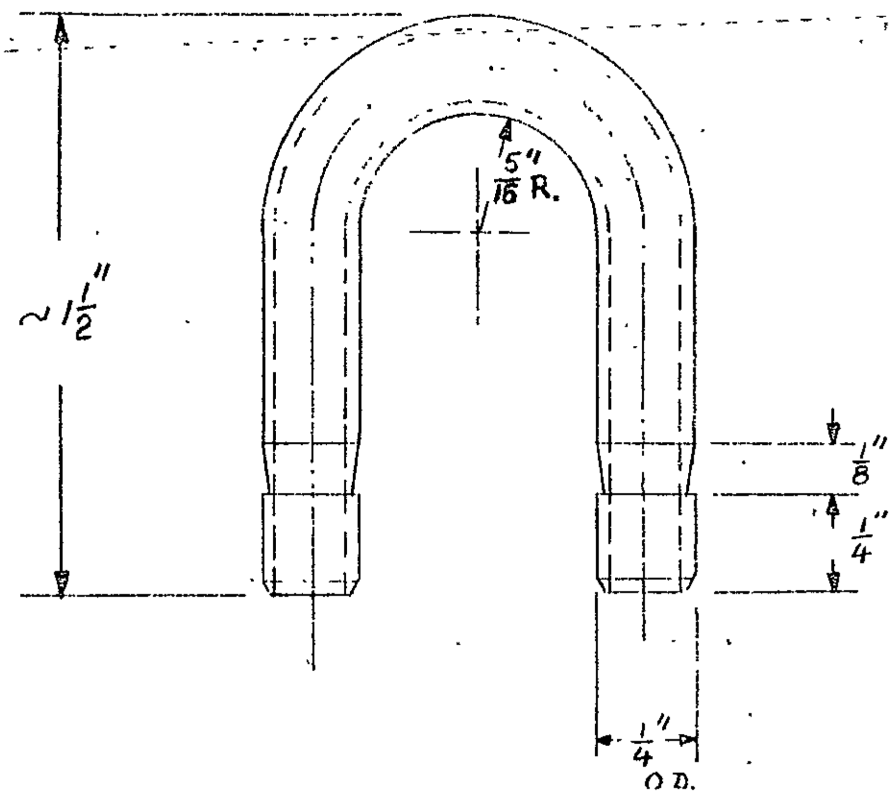
TITLE SUBHDR TAKE OF & U-BEND TUB.	Tool No.	DRN. 7-27-77	CALMAC MFG. CORP. Englewood, N.J.
		CHK.	
MATERIAL H.D. COPPER ALLOY #122, 1/4" O.D.	Blank Size	PROJ. SOL. COLL.	A- S117
		SCALE —	



Rev	By	Date	Revisions

TOLERANCES: FRACTIONAL, ± 1/64 ; DECIMALS, ±.005 ; ANGLES, ± 1/2°

TITLE STIMPSON CLAMP 'UPSETTING'	Tool No.	DRN. 7-28-77	CALMAC MFG. CORP. Englewood, N.J.
		CHK. *[initials]*	
MATERIAL STIMPSON CLAMP # 2048, CU.	Blank Size	PROJ. SOL. COLL	A-5119
		SCALE —	

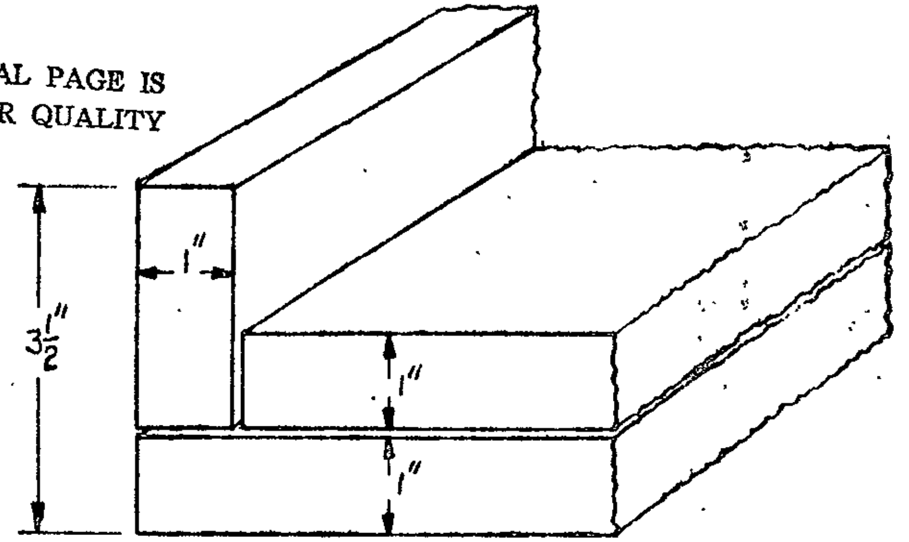


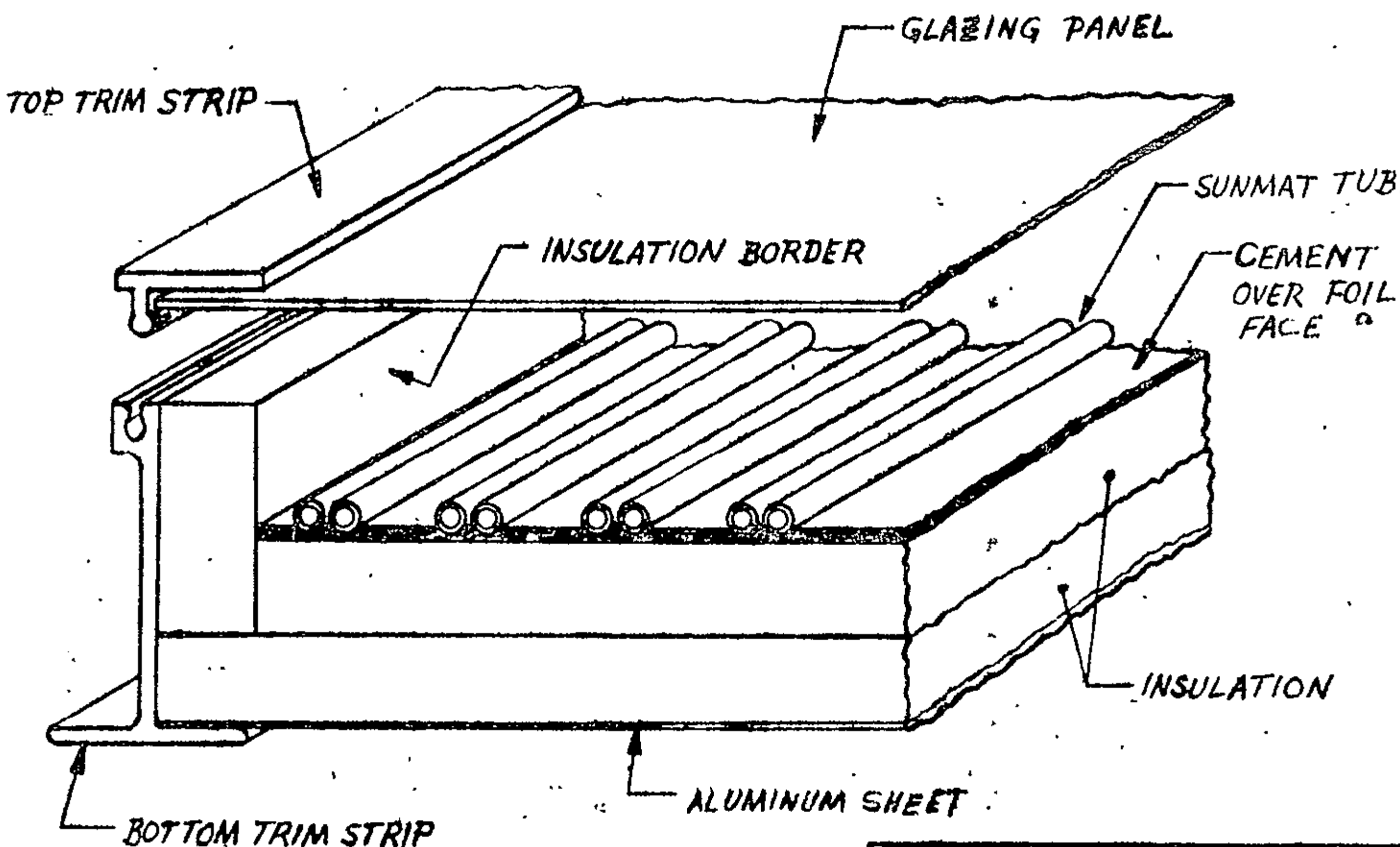
NOTE: REFER DWG. #AS117 FOR MORE DETAILED DIMENSIONS, ITEM #3
TUBING ANNEALED @ 500°F PRIOR TO BENDING.

Rev	By	Date	Revisions

TOLERANCES: FRACTIONAL, ± 1/64 ; DECIMALS, ± .005 ; ANGLES, ± 1/2°

TITLE COPPER 'U' BEND	Tool No.	DRN. 7-27-77	CALMAC MFG. CORP. Englewood, N.J.
		CHK.	
MATERIAL $\frac{1}{4}$" OD. H.D. CU. ALLOY # 122.	Blank Size	PROJ. SOL. COLL.	A-S118.
		SCALE 1" = $\frac{1}{2}$"	

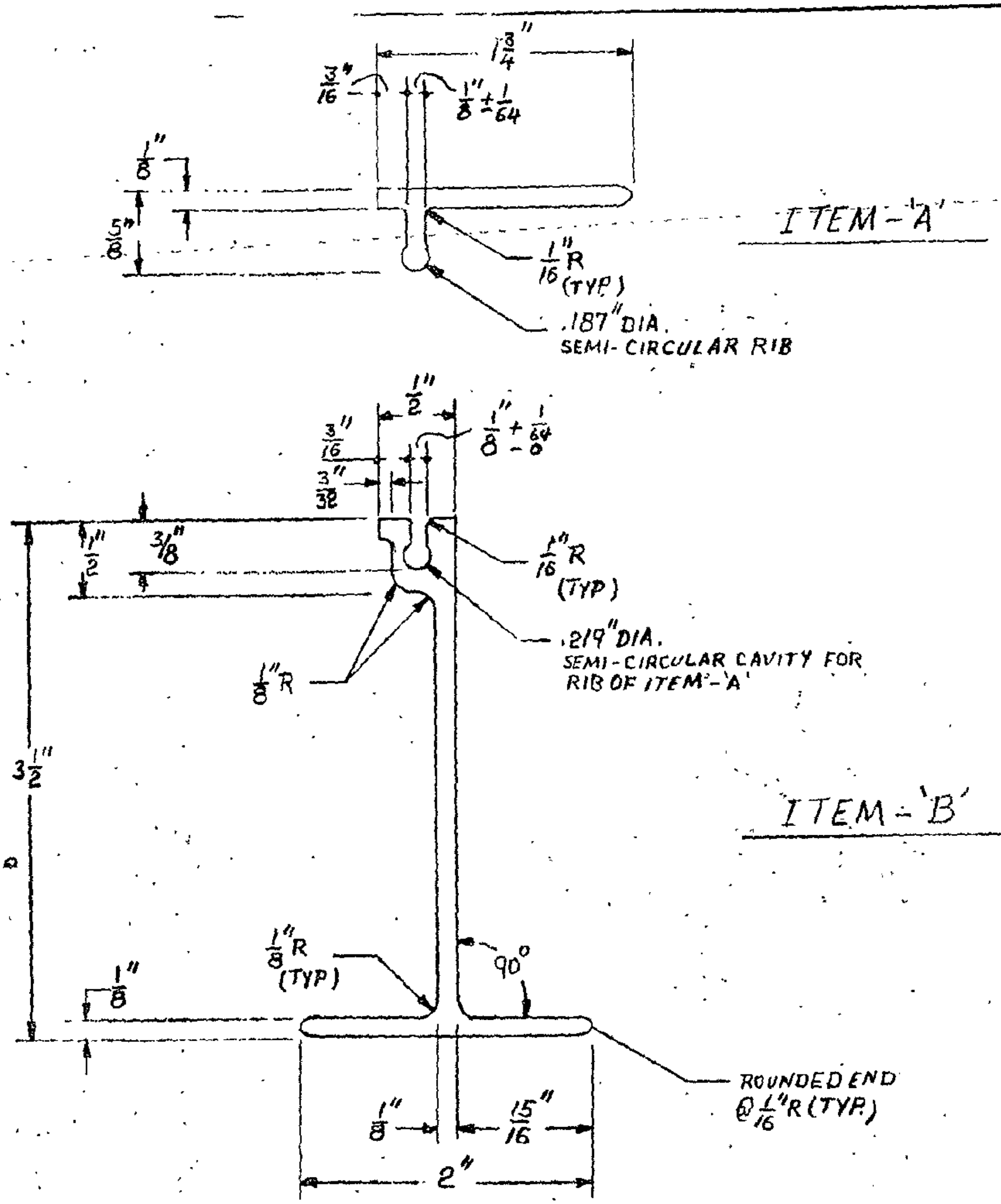




Rev	By	Date	Revisions

TOLERANCES: FRACTIONAL, ± 1/64 ; DECIMALS, ± .005 ; ANGLES, ± 1/2°

TITLE ASS'LY DETAIL, COLL. PANEL	Tool No.	DRN. 9-2-77 CHK.	CALMAC MFG. CORP. Englewood, N.J.
MATERIAL	Blank Size	PROJ. SOL. EN'GY SCALE —	A- S126



COLOR: BLACK
FILL WITH CARBON BLACK

Rev.	By	Date	Revisions

TOLERANCES: FRACTIONAL, ± 1/64; DECIMALS, ± .005; ANGLES, ± 1/2°

TITLE TRIM STRIP, TOP & BOTTOM	Tool No.	DRN. 8-31-77	CALMAC MFG. CORP. Englewood, N.J.
		CHK.	
MATERIAL H. DENSITY POLYETHYLENE	Blank Size	PROJ. SOL. EN'GY	A-S106
		SCALE FULL	

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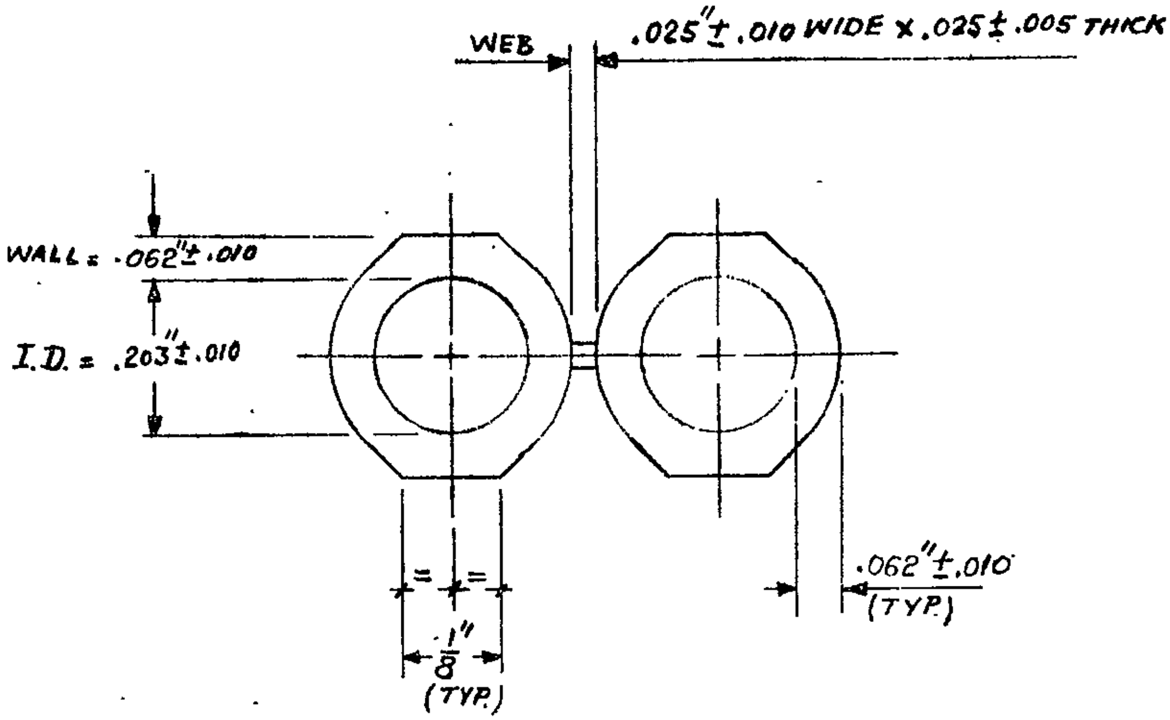


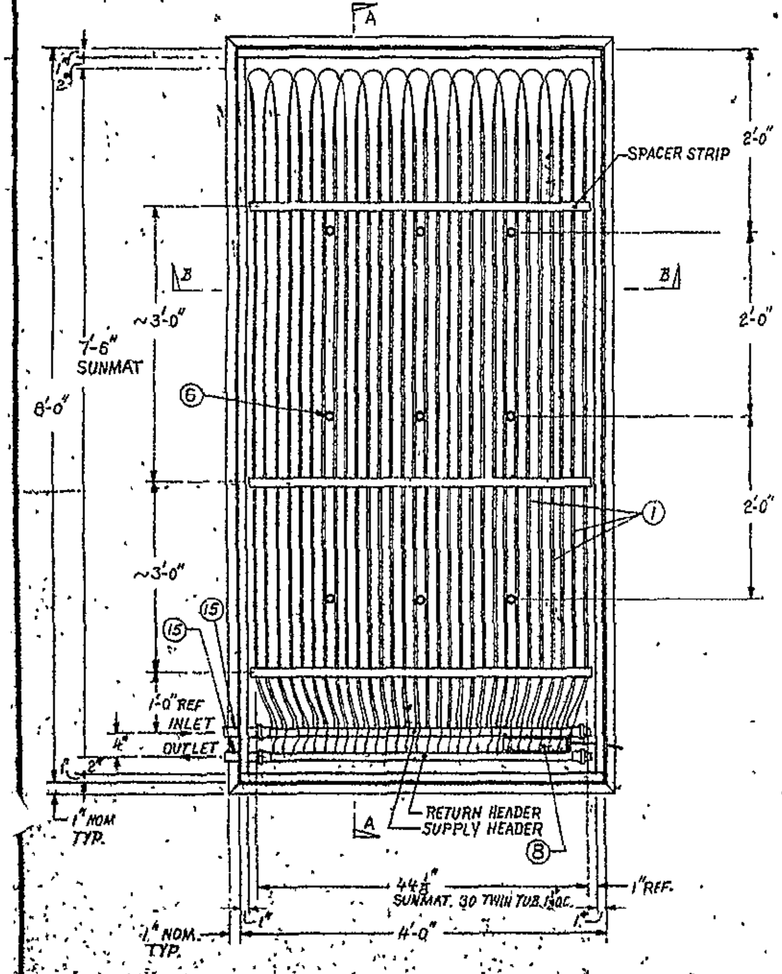
EPDM rubber dual tubing
Tensile strength, 1000-1200 psi
Elongation, 100-150%
Durometer(shore AZ hardness) 84-88
100% Modulus 900-1000 psi
Color- Black
Carbon black 50% loading
Cure continuous salt bath
Reel capacity 2200 ft.
Compression set 30%
Ozone resistance 0 ASTM
Non-staining
Non-fire resistant
Non-oil resistant

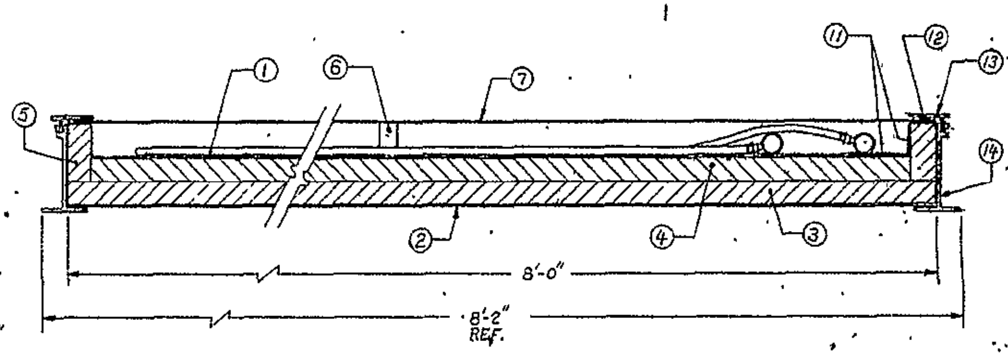
Rev	By	Date	Revisions
B		7-1-77	WALL DIMN. & FLATENED PART DIMN. ADDED
A			MODIFIED

TOLERANCES: FRACTIONAL, ± 1/64 ; DECIMALS, ± .005 ; ANGLES, ± 1/2°

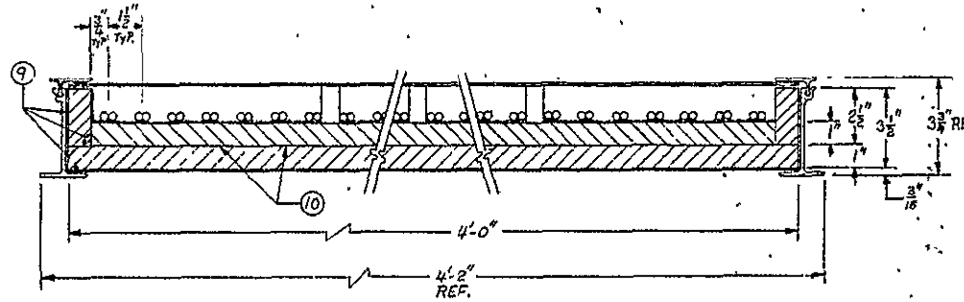
TITLE TWIN TUBING - CROSS SECTION	Tool No.	DRN. 12-13-75 CHK.	CALMAC MFG. CORP. Englewood, N.J.
MATERIAL 80-85 DUROMETER EPDM	Blank Size	PROJ. SOL. EN'GY SCALE 4=1	A- 130P-B

BILL OF MATERIAL			
ITEM	QTY	MATERIAL	REF.
1	1	SUNMAT ASS'LY WITH HDRS, W/O 'U' BENDS USING 30 TWIN TUBINGS INSTEAD OF 31 STD	C-156P FOR BASIC REF ONLY
2	1	AL. SHEET 4'x8'x.020"	STD
3	1	BOTTOM INSULATION BASE CONSISTS OF 4 2'x4'x1"THK 3# DENSITY FIBERGLASS INS'N BDS	OWEN CORNING LIT
4	1	TOP INSULATION BASE: 4'x8'x1"THK #703 FIBERGLASS INS'N WITH FSK ON ONE FACE, OUTGASSED	OWENS CORNING CO. LIT.
5	1	SET INS'N PERIMETER, MATERIAL AS ITEM 4	" "
6	9	SPACE BLOCK, 1"DIA. EPDM / BRAID HOSE, 1½"LG	STD ITEM
7	1	COVER PANEL, KALWALL SUNLITE PREMIUM, .025"THK	LIT KALWALL CO.
8	1	CONDENSATION DRIER	A-S108.
9	1 QT.	RUBBER ADHESIVE, 3M'S #1300	3M'S LIT.
10	1 GAL	FOSTER ADHESIVE # 85-15	FOSTER LIT.
11	1 GAL	UNIROYAL ADHESIVE # 12554 WITH CATALYST	UNIROYAL LIT.
12	24'	POLYSHIM TAPE 3/16"x½" WITH ⅛" SHIM	TREMCO LIT.
13	24'	TOP TRIM STRIP	A-S106
14	24'	BOTTOM TRIM STRIP	A-S106.
15	2	¾" BRASS NIPPLE, 5" LG	STD ITEM





SECTION-AA



SECTION-BB

Rev	By	Date	Revisions

TOLERANCES: FRACTIONAL ± 1/64; DECIMALS ± .005; ANGLES ± 1/2°

TITLE: SUNMAT SOLAR COLL. PANEL

MATERIAL: AS ABOVE

Tool No.

Blank Size

DRN. 9-12-77

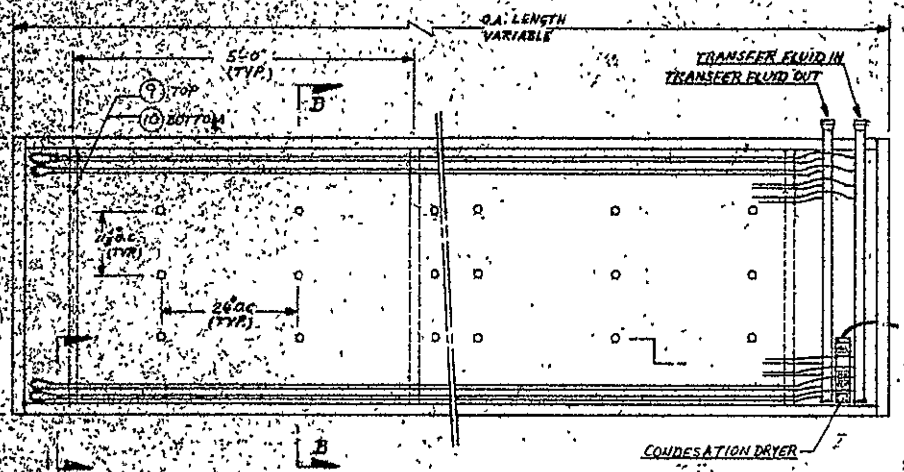
CHK.

PROJ. SOL. EN'GY

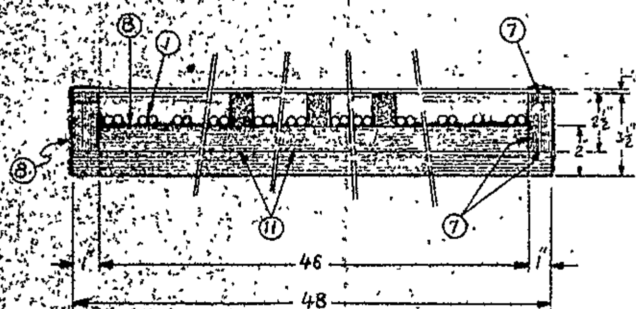
SCALE

CALMAC MFG. CORP.
Englewood, N.J.

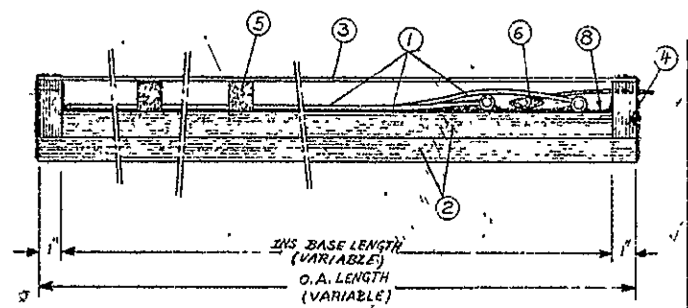
C-S125



TOP VIEW
SCALE: NONE



SECTION-BB
SCALE ¼=1"



SECTION-AA
SCALE: ¼"=1"

BILL OF MATERIAL			
REF DWG	ITEM	QTY	MATERIAL
C 156P	1	1	SUNMAT ASS'LY, COMPL WITH HDRS & U-BENDS
DATA SH'TS OWENS CORNING.	2 +	1	INSULATION BASE - 2, 1" THK INS. BDS. #703 OR EQUV., 5MIL AL FOIL ON ONE FACE
DATA SHTS KALWALL CO	3	1	COVER PANEL, KALWALL SUNLITE PREMIUM, .025" THK.
AS ITEM 2	4	1	SET INSULATION PERIMETER, MATERIAL AS ITEM 2
STD ITEM	5	1	SET SPACER BLOCKS, 1" DIA EPDM BLACK HOSE, SINGLE POLYESTER BRAID OR EQUV.
A-5108	6	1	CONDENSATION DRYER
DATA SHTS 3M CO	7	*	RUBBER ADHESIVE, 3M'S #1300 [illegible]
DATA SHTS UNIROYAL	8	*	UNIROYAL ADHESIVE #12664 WITH CATALYST #12198, BLACK COLOR
MANUFACTURER CATALOG	9	*	FSK (STD) DUCT TAPE, 1½" WIDE
KENDALL COMPANY'S DATA SHT	10	*	DOUBLE COATED POLYESTER FILM TAPE, 1½" WIDE POLYKEN TAPE #125 OR EQUV.
FOSTER DATA SH'TS	11	*	FOSTER ADHESIVE #8515

* QUANTITIES DEPENDENT ON SIZE OF COLLECTOR
ITEM #7: 40 FT²/GAL, ITEM 8: 40 FT²/GAL
ITEM #9: 4 FT/5 FT COLL. LGTH, ITEM #10: 4 FT/5 FT COLL
+ ITEM 2 MUST BE OUT-GASSED BY HEATING IN AN OVEN AT 350°F FOR ONE HOUR

NOTE:-

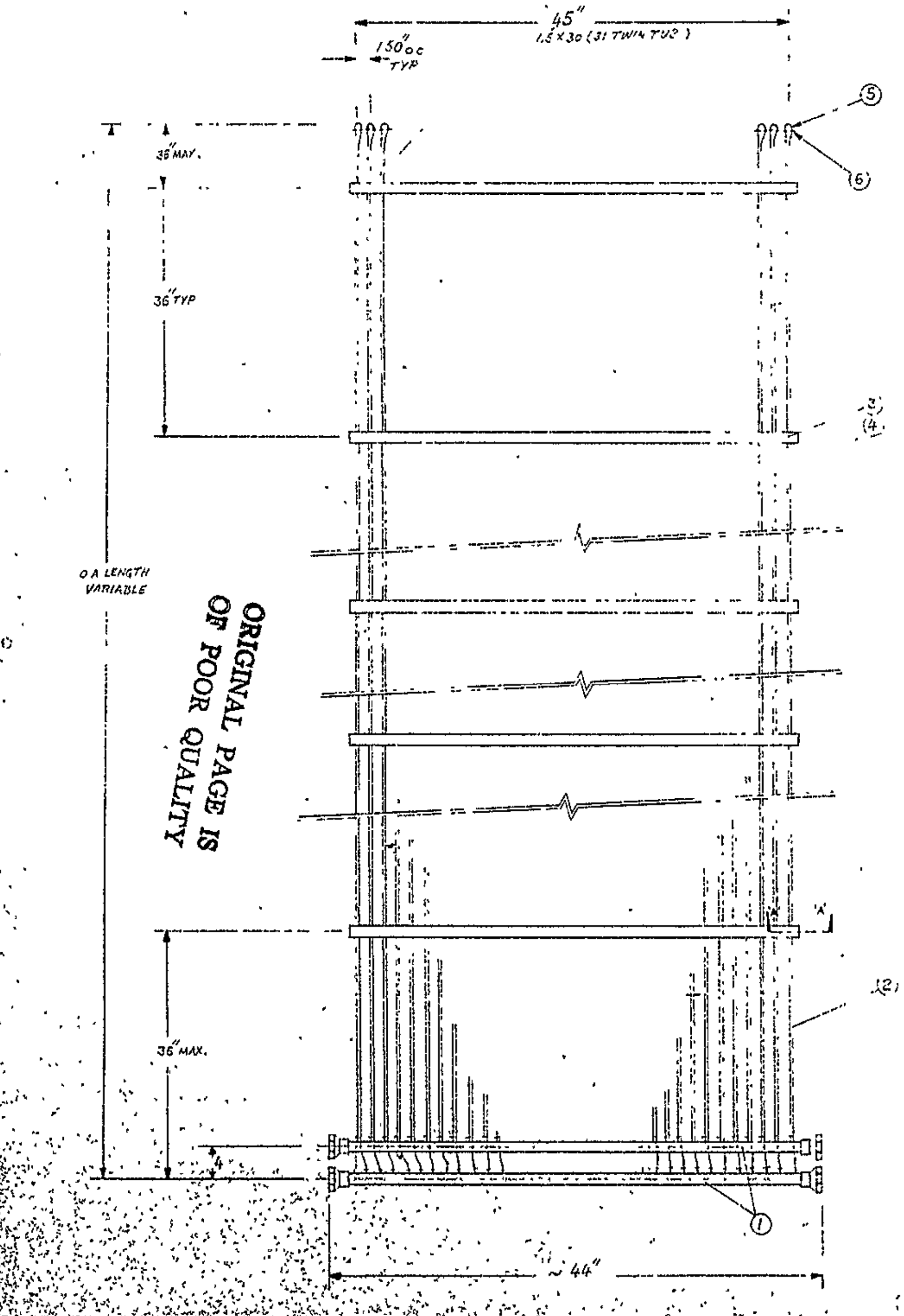
1- ITEM #7, ADHESIVE #1300 IS USED TO JOIN INSULATION PERIMETER TO BASE AND FOR JOINT BETWEEN INSL. PERIMETER AND COVER PANEL. ITEM 11, FOSTER ADHESIVE #8515 IS USED TO ADHERE 2 LAYERS OF INSULATION.

2- FOLLOWING MODIFICATION MADE IN THIS DWG
- 2ND LAYER OF GLAZING OMITTED WITH ATTACHING COMPONENTS. - ITEM 6 & ITEM 8 ARE CHANGED
- ITEMS 9 & 10 ADDED.
- COATING OF UNIROYAL ADDED ALL AROUND PERIMETER.

Rev	By	Date	Revisions
B	[illegible]	7-27-77	MODIFIED
A	[illegible]	5/25/77	MODIFIED

TOLERANCES: FRACTIONAL ± 1/64; DECIMALS ± .005; ANGLES ± 1/2°

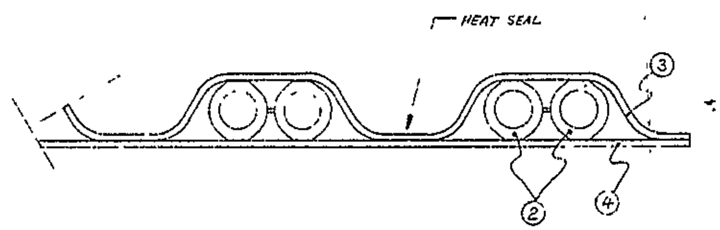
TITLE SUNMAT SOLAR COLLECTOR ASS'LY	Tool No	DRN. 12-29-76	CALMAC MFG CORP. Englewood, N J
		CHK [illegible]	
MATERIAL AS SPEC.	Blank Size	PROJ SOL ENGY	C-155 P-B
		SCALE GIVEN	



BILL OF MATERIAL

REF DWG	ITEM	QTY	MATERIAL
B-ST277	1	2	COPPER HEADER ASS'LY WITH 2 ADAPTERS & 32 NIPPLES
A-130P	2	*	EPDM TWIN TUBING 1/4" ID, 5/16" O.D. (BLACK)
	3	*	FLEXIBLE VINYL SPACER STRIP, .030" x 1" x 46", BLACK
	4	*	RIGID VINYL SPACER STRIP, .040" x 1" x 46", BLACK
A-S118	5	31	COPPER U-BEND, FROM 1/4" O.D., .032" WALL COPPER TUB
A-S119	6	124	STIMPSON BUTTON, CLAMP, # A2098 (COPPER)

* QUANTITY VARIES AS PER SPECIFIED LENGTH OF THE SUNMAT



SECTION - 'AA'

Rev	By	Date	Revisions
B		7/28/77	SECTION-'AA' ADDED
A		5/19/77	MODIFIED 31 TUB WERE 32

TOLERANCES: FRACTIONAL ± 1/64; DECIMALS ± .005; ANGLES ± 1/2°

TITLE "SUNMAT" ASS'LY	Tool No	DRN 12-29-76	CALMAC MFG CORP Englewood, N.J.
		CHK	
MATERIAL AS SPEC.	Blank Size	PROJ SOL. EN'GY	C-156P-B
		SCALE NONE	

WARRANTY

LIMITED WARRANTY

ORIGINAL PAGE IS
OF POOR QUALITY

PRODUCT: SUNMAT Solar Collector Panel

CALMAC MANUFACTURING CORPORATION warrants to the OWNER of this product that CALMAC will furnish a replacement for any other part which has failed in normal use and service because of any defect in material or workmanship.

DURATION OF WARRANTY: 1 year

~~NOTE THAT ANY~~ WARRANTY REPLACED ITEM CARRIES ONLY THE UNEXPIRED PORTION OF THE ORIGINAL WARRANTY

OWNER RESPONSIBILITIES

THE OWNER MUST:

1. Have the collector panel installed with a pressure and temperature valve and in accordance with local codes and ordinances.

2. Operate the collector panel at pressures below that shown in the Operating Manual.

3. Use a heat transfer fluid that is not corrosive.

HOW TO MAKE A CLAIM

Any claim under this warranty should be made to the contractor or dealer from whom the collector panel was purchased. If this cannot be done, the factory should be contacted directly.

Any item to be replaced MUST BE made available for inspection in exchange for a replacement.

ITEMS NOT COVERED BY THIS WARRANTY:

CALMAC MANUFACTURING CORPORATION WILL NOT BE RESPONSIBLE FOR:

1. Any damage resulting from water leaks or accidental discharge from fittings or valves.

2. Any claims resulting from loss of use of the unit, inconveniences, loss or damage to personal property or consequential damage.

3. Any illness or injury resulting from use of toxic heat transfer fluid.

4. Any labor charges for removal or reinstallation.

CALMAC MANUFACTURING CORPORATION
Box 710, 150 S. Van Brunt St., Englewood, N.J. 07631 • (201) 569-0420 • (212) 580-0178

5. Failure resulting from:

   a. Installation of unit without a properly installed pressure and temperature relief valve.

   b. Use of a corrosive heat transfer fluid.

   c. Exposure to freezing temperatures.

6. Any shipping costs, either of the replacement unit or part to the owner, or of the defective unit to the CALMAC factory.

MISCELLANEOUS

No one is authorized to make any other warranty on CALMAC Manufacturing Corporations behalf. Any implied warranty, including merhantability or fitness for a particular purpose shall not extend beyond the warranty period from the date of original installation.

In the absence of suitable proof of installation the effective date of this warranty will be based upon the month of manufacture plus three (3) months.

This warranty gives you specific legal rights. You also have implied warranty rights. In the event of a problem with warranty service or performance, you may be able to go to a small claims court, a State court, or a Federal district court.

OWNERS RECORD---RETAIN IN YOUR FILE

Name of Owner	Name of Dealer
Address of Owner	Address of Dealer
Model No.	Serial No.

Date of Installation

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